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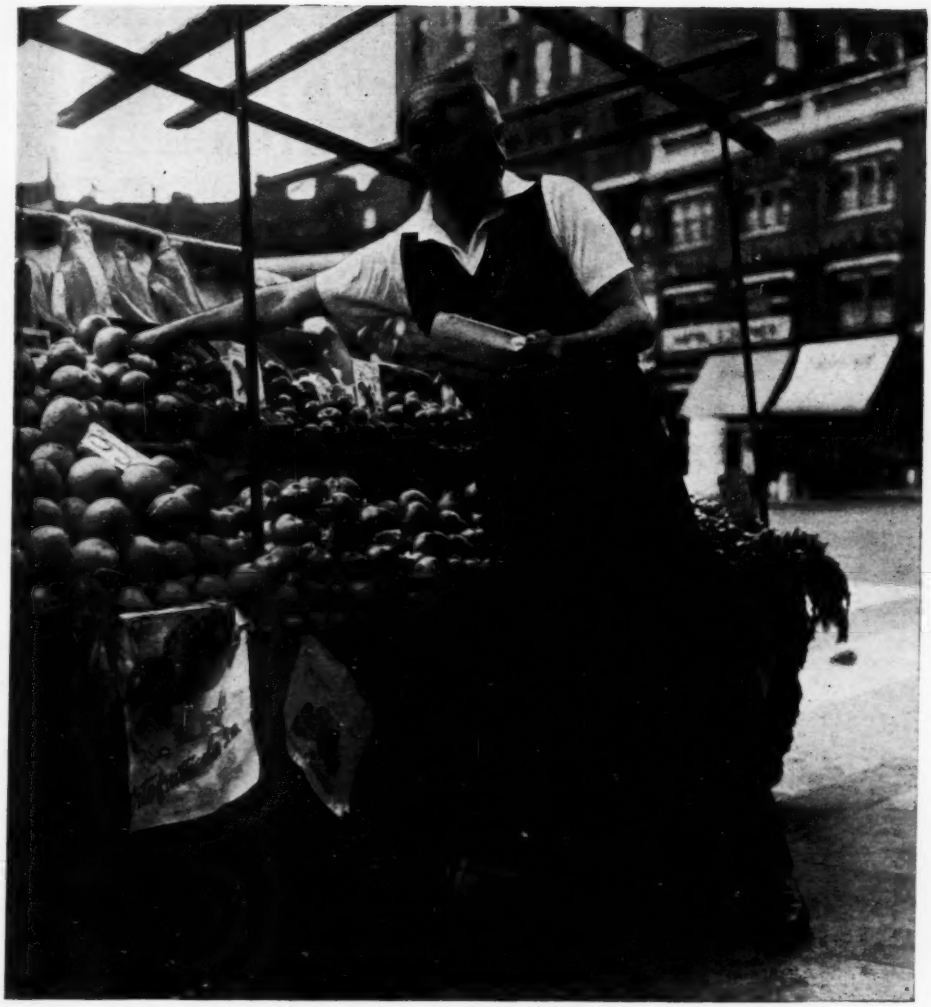

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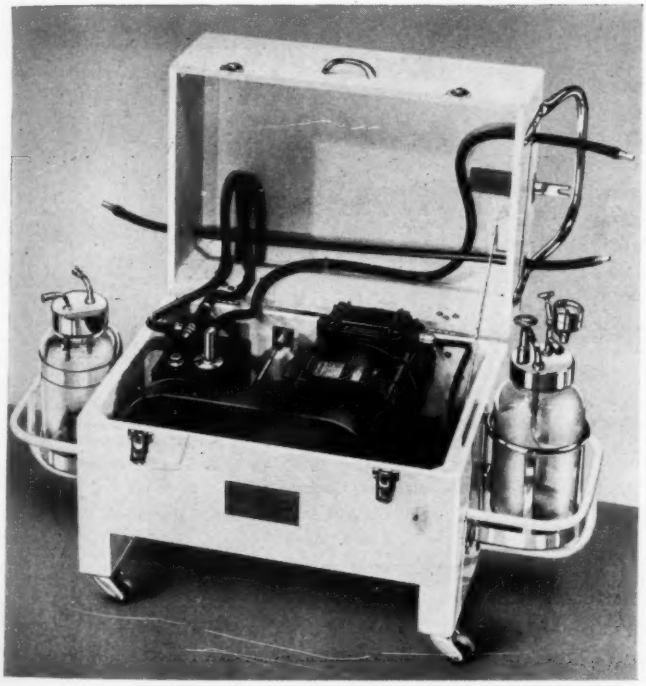

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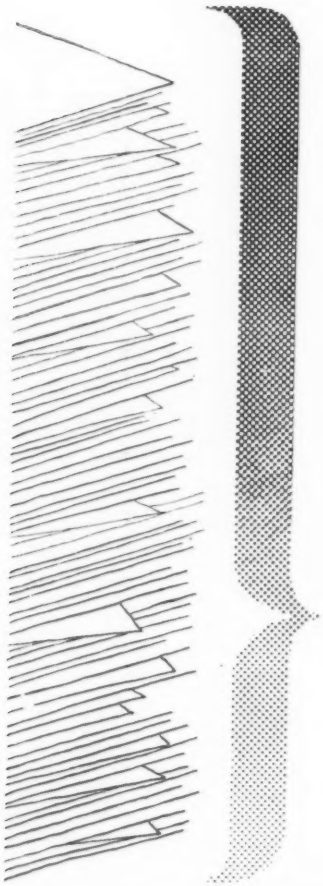

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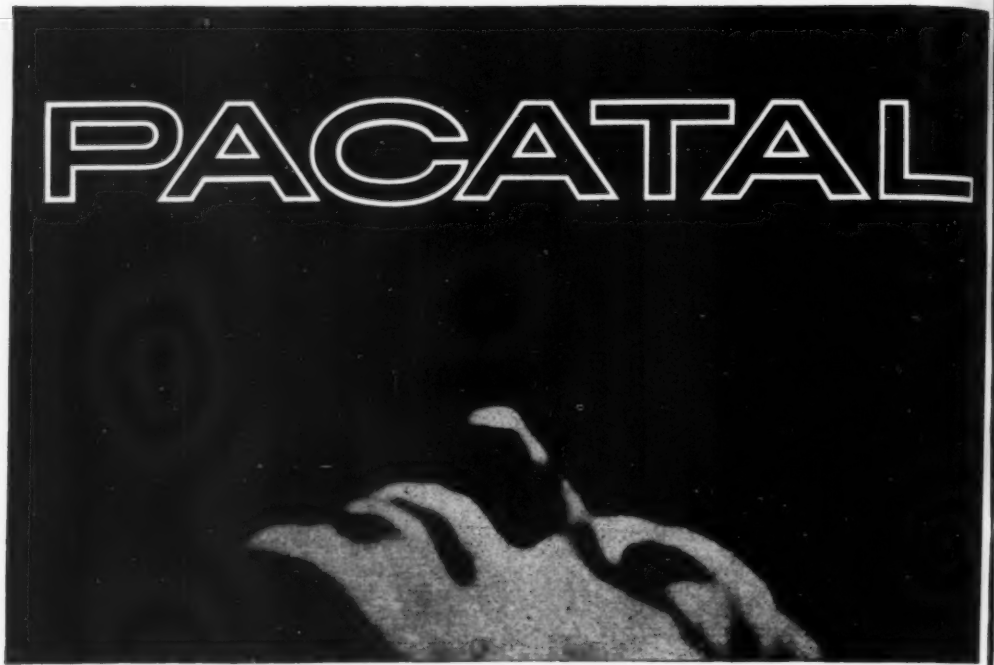

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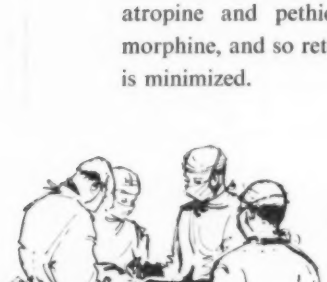

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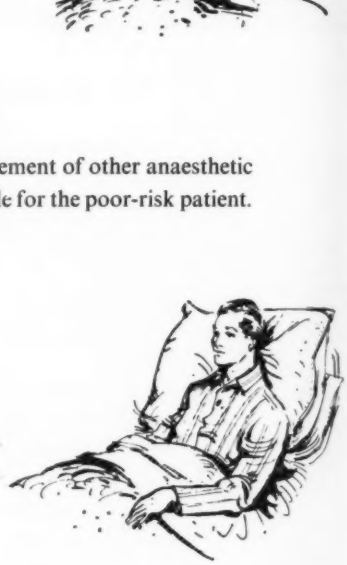

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BRITISH JOURNAL OF ANAESTHESIA

VOL. XXIX, No. 9 SEPTEMBER 1957

EDITORIAL

ADULT TECHNIQUES FOR THE CHILD

"WHAT'S sauce for the goose is sauce for the gander." A proverb which has apparently not received the attention it deserves from British anaesthetists today. In last month's issue a paper by Dr. Doughty on anaesthesia for adenotonsillectomy would appear to have drawn our attention to the truth of this doctrine.

Doughty has drawn up a comparison between what we might term a traditional method of anaesthesia for tonsillectomy, and a method based on the sort of rational concepts and reasoning which we have come to apply to our anaesthetic techniques for other surgical procedures.

Most of us were taught, very early in our anaesthetic careers, that one of the positive indications for endotracheal intubation was the possibility of fluid in the nasopharynx, whether that fluid be vomit from an intestinal obstruction or blood from an operation on the nasopharynx. Yet most of us have been content to see the operations which give rise to the most nasopharyngeal haemorrhage performed under some sort of oral insufflation technique. The reason for this blind spot in the vision of the present-day anaesthetists is difficult to understand, although, no doubt, the myth of the hazards of intubation in children is possibly to blame.

It is not just the question of intubation which is raised in Doughty's paper, but the whole approach to paediatric anaesthesia. He touches on the advisability of bringing the child to the theatre asleep, a doubtful benefit if this means that the child will remain for several hours post-operatively in the nightmare state of restlessness which is the almost inevitable result of heavy barbiturate premedication, a state in which the child is much more vulnerable to psychic trauma than the one who recovers quickly and fully to a state of complete orientation.

There may well have been a place for heavy premedication in the days when the child was subjected to all the horrors and anxieties of an inhalation induction of anaesthesia, but with the modern intravenous drugs available to us now, and the high quality of intradermal types of needle, an intravenous induction of anaesthesia is possible without any distress to the child and, with the short acting relaxant drugs, intubation is performed easily, safely and more rapidly.

It is to be hoped that Dr. Doughty's paper will help to make the use of anaesthetic techniques so satisfactorily employed in adults available to more of our younger patients.

Brit. J. Anaesth. (1957), **29**, 390

HYPOTHERMIA IN THE NEWBORN: BODY TEMPERATURES FOLLOWING ANAESTHESIA

BY

GORDON G. FRANCE

Royal Hospital for Sick Children, Glasgow

WITH modern anaesthetic techniques, surgical operations on newborn infants may last several hours. The fall in body temperature may be severe, reaching levels comparable with those normally achieved by deliberate hypothermic techniques.

During the period December 1956 to May 1957 the immediate postoperative rectal temperatures of twelve newborn infants, operated upon at the Royal Hospital for Sick Children, Glasgow, ranged (table I) from 97°F (36.1°C) to 83.5°F (28.6°C).

Thirteen operations, of one half to three hours duration were performed. The theatre temperatures varied between 70°F (21°C) and 80°F (27°C).

PROCEDURE

The babies were unclothed during operation, and on twelve occasions no attempt was made either to raise or lower the body temperature artificially. On the other occasion the infant was cooled by the external application of crushed ice. On the former twelve occasions the babies were anaesthetized with cyclopropane, nitrous oxide and oxygen by the semiclosed method without carbon dioxide absorption (France, 1957). Nitrous oxide, oxygen and gallamine triethiodide were used on the latter occasion. All were intubated with 00 Magill armoured endotracheal tubes.

Immediately after operation the infants were placed, unclothed, in an incubator already warmed and oxygen was supplied as required. The humidity control of the incubator was set at maximum and the rewarming process begun.

The intention was to restore the rectal temperature to 97°F (36.1°C) or 98°F (36.7°C). This generally took two to four hours and required incubator temperatures up to 100°F (37.8°C) or 110°F (43.3°C). The incubator temperature was thereafter adjusted so that the babies' rectal temperatures remained at about 97°F (36.1°C) or 98°F (36.7°C) and were not normally allowed to rise above 99°F (37.2°C) or fall below 96°F (35.6°C).

As well as rectal temperatures, respiratory rates and incubator temperatures were usually charted. Some of these charts are reproduced here (charts 1–9).

OBSERVATIONS

All the infants, even those whose temperatures were below 90°F (32.2°C) were awake and able to cry within a few minutes of the end of the operation. They were, however, drowsy and less vigorous in response to stimuli than before operation. When the rectal temperatures reached 95°F (35°C) or 96°F (35.6°C) an appreciable change was noted, the infants becoming much more active, crying and apparently feeling pain from the operation sites.

In those patients whose rectal temperatures had fallen below 90°F (32.2°C), there was little or no cyanosis. Some cyanosis of the extremities often developed when rectal temperatures of 95°F (35°C) or 96°F (35.6°C) were recorded. This peripheral cyanosis usually persisted until temperatures of 97°F (36.1°C) or 98°F (36.7°C) had been maintained for a short period.

The pre-operative respiratory rate of these newborn infants, though subject to much variation, was about 40 per minute. As can be seen from the charts (1–9) the respiratory rate tended to be about 20–30 per minute when the rectal temperature was 90°F (32.2°C) or lower; 30–40 per minute when 91°F (32.8°C) to 94°F (34.4°C); 40–50 per minute when 95° to 98°F (35° to

TABLE I

Initials	Sex	Age	Weight		Operation	Duration of anaesthetic	Postoperative rectal temperature		Maximum incubator temperature recorded		Time taken for rectal temperature to reach 97°F	Fatalities (days postoperative)
			lb	oz		Hours	°F	°C	°F	°C	Hours	
R.C.	M	1 day	3	1	Duodenal atresia. Anastomosis.	1½	91	32.8	110	43.3	8	2 days
M.G.	F	1½ days	3	2	Ileal atresia. Resection and anastomosis.	1¼	86.2	30.1	108	42.2	5½	1 day
R.A.	M	2 ,,	3	10	Tracheo-oesophageal fistula. Repair and anastomosis.	3	84	28.8	95	35.0	not attained	3 days
G.M.	F	2 ,,	4	0	Meconium peritonitis. Laparotomy.	1	91	32.8	103	39.4	7½	1 day
P.T.	M	7 ,,	5	4	Tracheo-oesophageal fistula. Repair and anastomosis.	3	85	29.4	104	40.0	2	
B.G.	M	2 ,,	5	12	Tracheo-oesophageal fistula. Repair and anastomosis.	2	87	30.5	102	38.9	4	5 days (10 days after first operation)
	M	7 ,,			Thoracotomy and gastrostomy. (Rupture of anastomosis).	1	91	32.8	104	40.0	3	
J.J.	M	3 ,,	6	1	Duodenal atresia and malrotation. Correction and repair.	1¼	90	32.2	100	37.8	1½	
J.A.	M	1 ,,	6	5	Imperforate anus. Abdominoperineal. Resection and repair.	1¼	95	35.0	unknown		3	
P.L.	M	4 ,,	7	1	Imperforate anus. Abdominoperineal. Resection and repair.	2¼	87	30.5	100	37.8	4	
D.D.	M	16 hrs.	7	8	Left diaphragmatic hernia. Repair.	1	93.5	34.2	98	36.7	4	
M.C.	M	8 days	8	3	Sacral teratoma. Removal.	1	97	36.1	not required		nil	
A.F.	M	14 ,,	6	5	Coarctation of aorta and patent ductus arteriosis. (Cooled artificially.)	3	83.5	28.6	102	38.9	3	

36.7°C), and above 50 when the temperature was 99°F (37.2°C) or more. Over a period of time, varying from hours to days, the rate then returned to about the normal 40 per minute.

When the duration of the operation was less than two hours, the average postoperative temperature was 91.8°F (33.2°C). When the duration was more than two hours the average was 85.75°F (29.8°C), a difference of about 6°F (3.4°C). The average in infants under 5 lb (2.25 kg) weight was 88°F (31.1°C), and in those over 5 lb 90.7°F (32.6°C). This shows a difference of 2.7°F (1.4°C) though the operating times in the two groups were similar.

Records of the rectal temperatures, incubator temperatures and respiratory rates of patients referred to in table I are shown in charts 1 to 9.

Charts 1 to 4 show characteristic patterns of rewarming, when the rectal temperature was restored to 97°F (36.1°C) within four hours.

The record of the second operation of the patient B.G. shows a persistently raised respiratory rate and some pyrexia related to the unrepaired rupture of the oesophageal anastomosis and consequent pleurisy with effusion.

The left lung of the patient D.D. was unexpanded due to the extensive diaphragmatic hernia present before operation. The hernia consisted of stomach, spleen, the entire small bowel and transverse colon. In addition, it was later discovered that the patient had a patent ductus arteriosus, atrial septal defect and malrotation of the colon. The effect of these factors is shown in the exaggerated respiratory response to rise and fall in rectal temperature. The left lung reexpanded over a period of two weeks and the respiratory rate gradually fell to 40 per minute. Bigler and McQuiston (1951) state "With every degree of temperature (F°) change there is a change in metabolism of 7 per cent."

Chart 5 shows the temperature and respiratory rate of a patient (R.A.) who failed to rewarm above 93°F (33.9°C) though the incubator temperature ranged from 85 to 95°F (29.4 to 35°C). The infant remained a good pink colour, conscious and moving about, but rather lethargic. He breathed evenly and steadily at 20 to 30 respirations per minute until he died on the third postoperative day. No urine was passed after operation, and sclerema developed. Autopsy showed bilateral renal congestion, necrosis and venous thrombosis.

R.C. (chart 6) appeared to be making satisfactory progress in spite of a slow rewarming until, owing to incubator failure, he was transferred to another incubator the temperature of which was 10 to 12°F (5.5 to 6.6°C) lower. An immediate rise in respiratory rate and slightly delayed fall in rectal temperature followed this transfer and the infant died within a few hours. Autopsy showed wide atrial and ventricular septal defects, congestion of the liver and slight oesophagitis.

Difficulty in maintaining an adequate incubator temperature caused considerable delay in rewarming G.M. (chart 7). Postmortem examination showed small subdural haemorrhages over each cerebrum, probably due to birth trauma, also a low grade round cell oesophagitis. Neither at operation nor postmortem was a perforation of the bowel detected, though a small quantity of meconium was present in the abdominal cavity at operation.

Some delay occurred in rewarming M.G. chart 8), but the stormy postoperative course and death were due to necrosis of the proximal segment of the ileal anastomosis.

Chart 9 (A.F.) shows the temperature record (on a different scale) of a patient operated on by resection and anastomosis for coarctation of the aorta. Incubator rewarming was satisfactory and the patient made a good recovery.

MORTALITY

Of the five deaths in this series of twelve patients, two (B.G. and M.G.) were directly attributable to surgical causes. In two others failure to rewarm (R.A.) and stress due to transfer to a colder incubator (R.C.) may have been important factors in causing death, though more mature infants might have survived these complications. The cause of death of the other patient (G.M.) is unknown: birth trauma, prematurity, delay in rewarming and mild infection may all have been contributing factors.

None of the infants who were rewarmed within four hours of the end of the operation died, but there were not any under 5 lb (2.25 kg) in weight in this group.

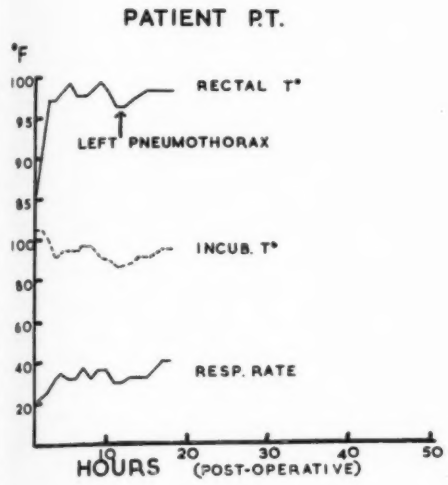


CHART 1

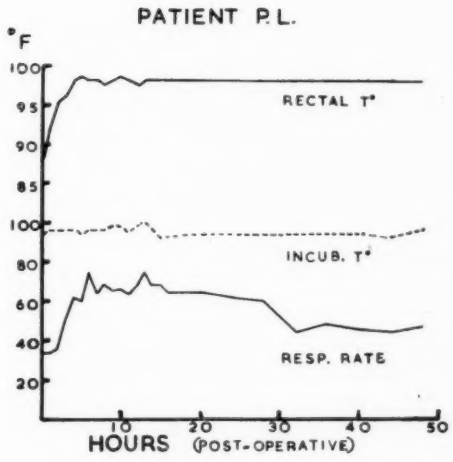


CHART 2

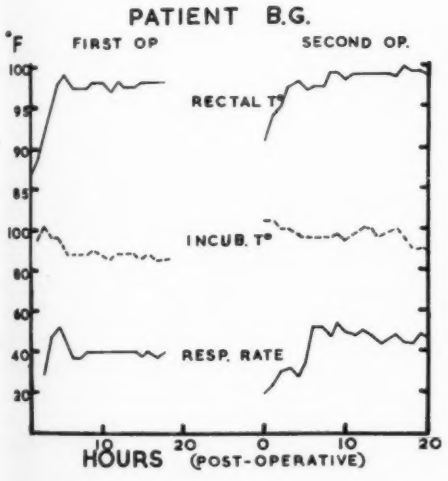
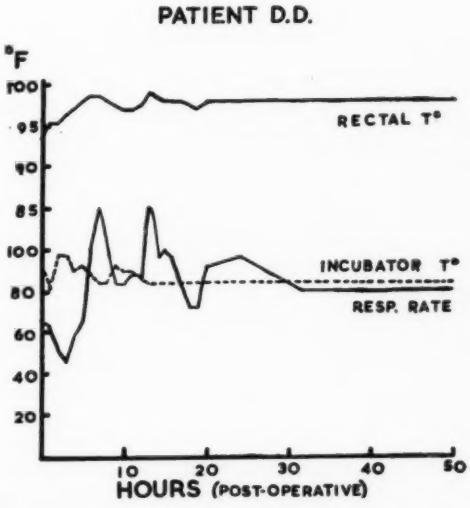


CHART 3



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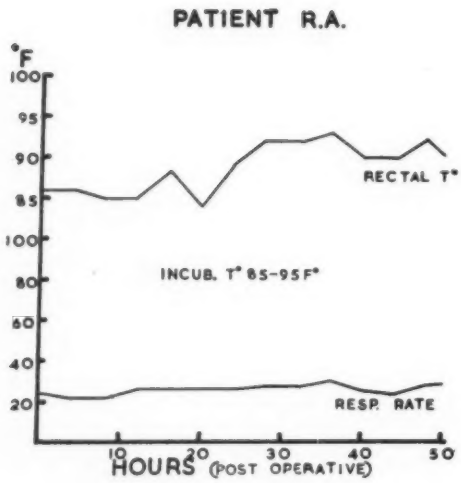

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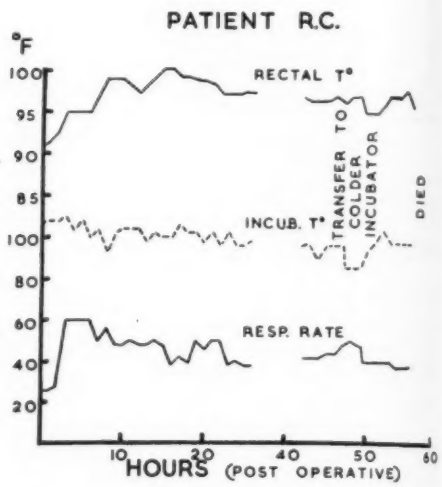

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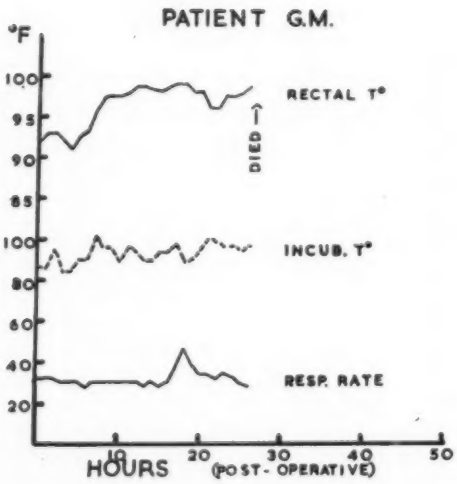

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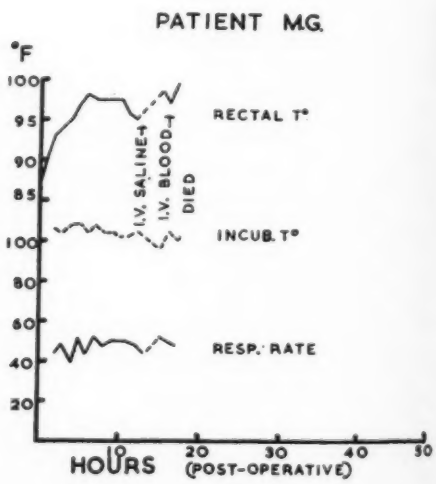

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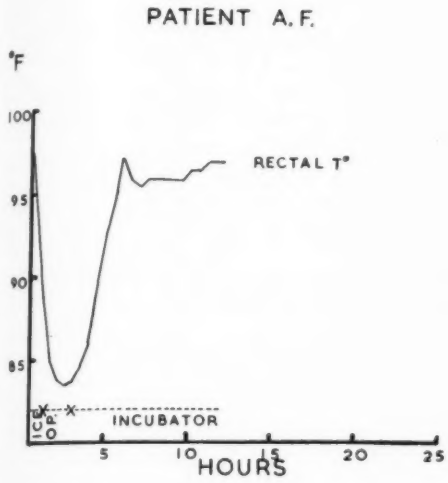

CHART 9

The results show that successful recoveries from hypothermia during surgical operations may be made by infants over 5 lb (2.25 kg) in weight. The evidence regarding the smaller infants is inconclusive.

DISCUSSION

It is well known that the body temperature of newborn infants may fall during a surgical operation under general anaesthesia.

Bigler and McQuiston (1951) found that, in their control group, which was not subjected to artificial cooling, the rectal temperatures of six infants under two weeks old fell to 93°F (33.9°C), 94°F (34.4°C), 95°F (35°C) (three infants) and 97°F (36.1°C). Stephen (1954) states: "It is not unusual for a baby's temperature to be 95°F after a two or three hour surgical procedure." Gross (1953) says: "The body temperature of a small infant can readily fall to 90°F in a cool operating room, or rise to 105°F in an overheated one."

The extent of the fall, 1 to 15°F (0.5 to 8.3°C), in this series of cases is materially greater than these authors record.

From such a small number of patients firm conclusions should not be drawn but the following points are noted. The degree of the fall appears to bear a closer relationship to the duration of the anaesthetic than to body weight. A general relationship between respiration and body temperature is apparent.

Small premature babies are unable to maintain their body temperature without external warmth. Incubator temperatures up to 100°F (37.8°C) or 105°F (40.5°C) were required to rewarm babies of 5 lb (2.25 kg) or more in weight but higher incubator temperatures, up to 110°F (43.3°C), were required for those of 4 lb (1.8 kg) or less in weight. These temperatures may be difficult to attain with some incubators, and it may be necessary to resort to rewarming in a warm bath.

Smith (1945) describing an investigation into the body temperatures of 20 normal neonates states that: "Even though the infant is wrapped and placed in a warm room (80°–85°F) it undergoes an immediate loss of some 2° to 5°F, after which a rising trend sets in which carries the temperature up to 98° to 99°F in about eight hours." Not all babies can be so carefully treated at birth and there must be occasions when the fall in body temperature, especially of premature infants, is considerably greater than these figures.

The findings in this present series emphasize the necessity of taking frequent records of both the infant's rectal temperature and the incubator temperature. The ordinary clinical thermometer is useless as it does not register below 95°F. A low registering rectal thermometer is necessary, or preferably an indwelling thermocouple as this avoids repeated opening of the incubator to take the rectal temperature and thereby loss of incubator heat and moisture. A high humidity is of great importance in encouraging rewarming by reducing the loss of body heat through evaporation and moistening of the inspired air. The management of the body temperature, which is only a part of the postoperative care of the newborn, is time-consuming and requires a highly trained staff.

SUMMARY

Records of the body temperature after anaesthesia of twelve newborn infants are given. These temperatures ranged from 97° to 83.5°F (36.1° to 28.6°C). A method of rewarming is described and charts of rectal and incubator temperatures

and respiratory rates are illustrated. The results show that successful recoveries from hypothermia during surgical operations may be made by infants over 5 lb (2.25 kg) in weight. The evidence regarding the smaller infants is inconclusive. Some suggestions are made as to the care of infants in incubators.

ACKNOWLEDGMENT

My thanks are due to Mr. W. M. Dennison for his encouragement and permission to publish these records of his patients.

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Brit. J. Anaesth. (1957), **29**, 397

SURFACE COOLING

A New Method

BY

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THE production of hypothermia by surface cooling is simpler and perhaps intrinsically safer than either " body cavity " or pervascular cooling. It has been suggested that one advantage of pervascular cooling is freedom from tissue necrosis, due presumably to excessive local application of ice.

The method described below eliminates the need for application of ice or ice bags to the patient, and is the method now used at Frenchay for the production of hypothermia for selected neurosurgical cases. The lowest temperature reached is about 28.5°C; in view of our own and general experience, we do not allow the temperature to fall further.

Recovery is usually brought about by gentle warming, at the conclusion of surgery, by the administration of warmed anaesthetic gases, and then, when a temperature of about 31°C has been reached, by the use of an electric blanket.

Anaesthesia is continued, where practicable, during the earlier stages of warming, to try to minimize the tendency to violent reactionary shivering attacks, without recourse to post-operative sedatives.

TECHNIQUE

The patient is given atropine 0.6 mg half an hour before arrival in the anaesthetic room. Pre-anaesthetic sedation is rarely used, and only for psychical reasons.

Induction is by thiopentone 500 mg–1.0 gram, followed at once by d-tubocurarine chloride from 30 to 45 mg. Spontaneous respiration is completely abolished, intubation is performed at once, and controlled mechanical respiration begun.

Anaesthesia is continued with nitrous oxide and oxygen, about one-third oxygen, and about six litres per minute flow, using an M.I.E. circle absorber semiclosed. Morphine 15 mg and papaverine 60 mg are given intravenously. In cases where there is a known raised intracranial tension, 50 ml of 50 per cent sucrose are also given intravenously.

About five minutes later, the patient is placed naked and supine on a trolley, the top of which consists of stainless steel strips arranged in an open square lattice; under this trolley is a fixed watertight tray, with a drain outlet. The rectal thermometer is placed in position, and the cardioscope leads connected to the patient.

The patient is then irrigated gently from head to feet by means of a gentle spray of ordinary cold tap water (at about 25°C), through a length of hose provided with a garden sprinkler outlet. An electric fan, placed and insulated with due regard to the risks of electrocution, is allowed to blow its airstream down the length of the patient. This method will cool a thin or average adult in from one hour to one hour and a half to 32°C. A fat patient, or one who is already in hyperthermia from stem injury, will require somewhat longer, and may require more rolling to mobilize pooled blood. We have not taken longer than two and a half hours to cool any patient. The use of cold water instead of ice or ice bags removes any risk of " burns ", and since the cold is neither so intense nor so localized as an ice bag, however often moved, the formation of local cold patches in isolation does not occur.

The flow from the sprinkler should be only just sufficient to keep the patient wet all over, including the head and neck. If large amounts are used, the poor conductivity of water will tend to reduce the efficiency of cooling, as a warmer layer will tend to remain next to the skin and acts as an insulator.

Measurement of the temperature of the spray issuing from the nozzle, and the spray at the skin surface, shows a fall of 1 to 2°C in water droplet temperature during the short fall of about two feet from nozzle to patient; this is entirely due to evaporation of part of the water droplets as they fall, by the air stream from the fan.

The same effect can of course be obtained, and has been obtained, by irrigation of the patient submerged in a bath of water at the same temperature, provided that rapid surface flow all over the patient is maintained. To do this in a bath requires the use of phenomenally large volumes of water.

To use the cold shower does not involve the provision of complicated and expensive apparatus, and does not involve heavy handling of the patient. Supervision is easier, the emergency administration of drugs is easier and less potentially septic. The electrocardioscope can be used, provided the pick up needles are covered with waterproof elastoplast, without the appearance of electrical leakage disturbances.

If cooling is stopped at 33 to 32°C in our environment, a sufficient degree of aftercooling occurs to produce a rectal temperature of about 28.5°C, by the time the skull is open and maximum hypothermia is required.

No hypotensive drugs are used. A mild degree of hypotension of 10 to 20 mm Hg in the normotensive patient, together with regular bradycardia often down to 40 per minute, has occurred in our patients.

At the conclusion of the cooling phase, the patient is transferred to the operating table, and tilted into slight reversed Trendelenburg.

Should arterial bleeding occur, as for example during isolation of an aneurysm, the bleeding is usually controlled by manual compression of the carotids in the neck. This encourages the surgeon to bring matters under control in a reasonable time, instead of relying on the cover provided by hypothermia in the presence of circulatory inadequacy as yet not clearly defined.

The operating conditions provided by this type of general anaesthesia, employing mechanical respiration (with or without hypothermia) are sufficiently good to make deliberate arterial hypotension superfluous. The technique controls cerebral congestion by improved venous emptying of the skull, rather than by reducing arterial supply, and at least where cerebral compression is present, this would seem a reasonable approach.

DISCUSSION

Effectiveness of Water Spray Cooling.

Some explanation of the effectiveness of water spray cooling is afforded by consideration of the figures involved.

The average male basal heat production is 70 Calories per hour. (This refers to the resting quiet conscious patient, not the anaesthetized and fully curarized patient, in whom heat production must be considerably less as muscle tone and movement produce the most heat.) If undispersed, this would raise the body temperature by about 1°C per hour.

Evaporation of 1 litre of water removes 580 Calories as latent heat. Hence it is only necessary to evaporate about 125 ml of water per hour from the whole skin surface of the patient, to maintain normal heat balance by this means, provided that skin vascularity and general circulation are adequate. The specific heat of the body is almost unity (80 per cent water) and hence to decrease the temperature at the rate of 1 degree per hour would require a further evaporation of 125 ml water from the surface. To decrease the temperature by 4°C per hour which is about the rate of cooling required, would appear to need the efficient evaporation of only about 625 ml water. The evaporation of such a quantity in one hour from the large body surface, by the use of an efficient airstream, is quite practicable.

In moderate exercise, increases in heat production to five times normal are not uncommon, and are dealt with principally and adequately by the mechanism of sweating, that is to say by the evaporation of water from the skin. Artificial perspiration should be at least as effective as the natural function.

Curare, Morphine, and Papaverine.

Complete curarization, by removing muscular tone and movement, including that of the respiratory muscles, prevents shivering and removes the most considerable source of metabolic heat.

Morphine depresses metabolism, and heat

production, besides acting as a general sensory depressant of the nervous system and brain stem. The principal objection to its use, respiratory depression, is invalidated where mechanical respiration can be relied on. The autonomic response to cooling is depressed.

Papaverine appears to prevent the vigorous skin vasoconstriction which normally accompanies exposure to cold, in doses which do not produce serious falls of blood pressure. This skin response to cold, being a function of the axon reflex, is largely independent of the central nervous system. Papaverine depresses presumably the peripheral vascular smooth muscle activity. The hands and feet of these patients remain pink, during cooling, and cyanosis does not appear. As the temperature falls there is a gradual development of pallor. The nails remain pink, and capillary refilling remains reasonably brisk.

We have used this method only a dozen times, owing to shortage of suitable cases, but they have been characterized by an extremely smooth course, freedom from anxiety, and an uneventful rapid recovery. In most of these, rewarming has been begun at the end of surgery, and no period of prolonged postoperative cooling has been attempted. The improved circulatory stability, in contrast to cases in which chlorpromazine promethazine and pethidine and sedatives were used, is most striking.

SUMMARY

A method of surface cooling using a shower and fan is described. Curarization avoids shivering. Morphine helps to depress metabolism and is a central analgesic. Papaverine prevents skin vasoconstriction.

Brit. J. Anaesth. (1957), **29**, 400

A TEMPERATURE CONTROLLED CABINET OPERATING TABLE FOR SAFE HYPOTHERMIA

BY

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WE have endeavoured to find a method of hypothermia which is controllable and which, therefore, minimizes the dangers which exist. In particular, we have borne in mind the reversibility of many of the changes which occur under hypothermia, and have devised a means of utilizing this fact. Using this method it is possible to produce and maintain the temperature at whatever degree is decided upon pre-operatively as necessary for any particular patient.

In 1956, we started using ice-bath cooling and air rewarming and soon afterwards air cooling and air rewarming. Clinical experience was preceded by experimental work on dogs.

TECHNIQUE I

Ice-water surface cooling and air rewarming

This method of cooling was devised before the air cooling plant was available and because it was suitable for the majority of patients. Apart from the induction, which may be with an intravenous barbiturate, maintenance is preferably carried out with ether, which, being volatile, is readily eliminated by ventilation. Metabolic acidosis must be avoided by adequate anaesthesia and complete muscular relaxation. Respiratory acidosis must be prevented by adequate ventilation. In evaluating the optimal conditions for circulatory arrest, consideration must be paid to the inevitable changes in blood chemistry, which follow the period of arrest, a condition known as "post-clamp acidosis" (Neil, 1957).

After induction of anaesthesia two intravenous infusions are started and one arterial cutdown is made. The usual cooling technique is used, taking all the ordinary precautions; namely a surgeon should be ready to perform cardiac massage, constant checks should be made on e.c.g., blood pH, pCO_2 and electrolytes in order to regulate the pulmonary ventilation and degree of curarization. Frequent checks should be made of oesophageal and rectal temperatures and care is taken as to protection of the patient's fingers and toes by keeping them out of the ice water, carefully drying the skin after removal from the bath.

The temperature at which the patient is removed from the ice bath is usually 31–32°C and the ether anaesthesia can then be discontinued. The patient is placed on a mattress made of webbing, with adequate space between the bands to allow air to circulate in direct contact with the skin. This mattress, which was made by the hospital mattress repairer, can be slid along tracks inside a simple, wooden, insulated and thermostatically controlled box or cabinet. The box is of such a height, width and length that it is used as the operating table. Underneath the webbing mattress, inside the wooden box are three hair dryers, which can be switched on and off independently. Thermocouples placed inside the box allow constant observation of the temperature of the air circulating around the patient.

The box is partly closed off over its distal half by a deep wooden lid, which also serves as an instrument table during operation. The box can be completely closed off, when the operation is not in progress, by sliding along its upper ledges the proximal half of the lid, which is made of double walled transparent plastic material and which can be telescoped under the distal half of the lid. The transparent proximal half makes contact with an upright transparent plastic headpiece thus closing off the whole cabinet. There are openings

in the transparent lid and headpiece through which one arm or both arms can protrude with the patient lying in the lateral position or on his back. Thus the taking of blood samples and measurement of arterial blood pressure can be carried out as usual. Other small openings allow e.c.g. leads, oscillometer tubes, thermocouple leads and drip tubing, etc., to be led out of the cabinet. Temperatures in the upper half of this cabinet are also measured electrically (figs. 1, 2).

Should after-cooling continue, then rewarming of the patient can take place immediately, either from below only or, if necessary, by surrounding the whole patient with warm circulating air,

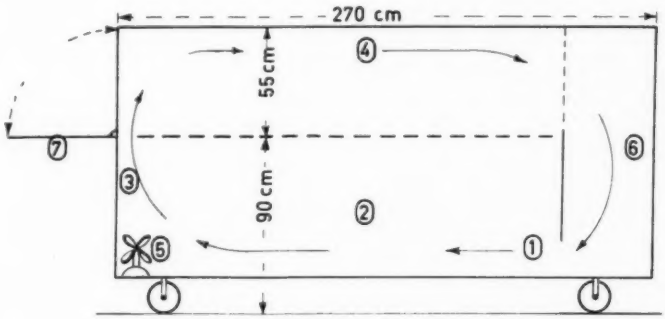

FIG. 1
Diagram of cabinet showing air circulation.
(1), (2), (3), (4), Thermocouples.
(5) Electric fan.
(6) Cooling machine.
(7) Head piece.

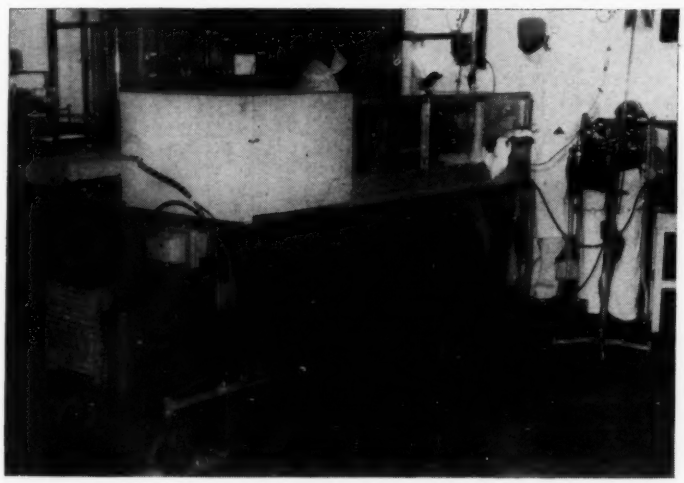

FIG. 2
Cabinet for air cooling and rewarming, with transparent lid.

simply by sliding the plastic lid proximally and closing off the cabinet. In this way good control of after-cooling is possible.

Once the intracardiac operation has been performed, rewarming from below is started immediately, while the surgeon completes the remainder of the intrathoracic part of the operation. Then at this point, all drapes are removed from the patient and the thorax wound is left open. A few pieces of gamgee, soaked in water are placed near the patient in order to keep the warm air humid. The transparent plastic lid is then pulled proximally so as to close off the cabinet and the temperature of the circulating air is brought up to 40–45°C.

Ventricular fibrillation is particularly liable to occur after the clamping period and the thorax is, therefore, left open until this danger is reduced by rewarming and by the return to safer values of pH, potassium, etc. The surgeon remains scrubbed up and prepared to deal with the ventricular fibrillation should it occur. The thoracic cavity is inspected frequently through the transparent lid for any changes in heart action (fig. 3). Haemorrhage, which is prone to occur in the hypothermic state, becomes evident in the thorax as the temperature and blood pressure of the patient rises. The surgeon is ready to take corrective measures for any complication in the few seconds necessary to slide the lid back.

Only when the patient's temperature is at least 35°C and the blood pressure within 10 per cent of its normal value is the decision taken to close the thoracotomy. This technique we have called "late closure" and we firmly believe that it greatly reduces many of the complications which are seen when the thorax is closed during the hypothermic state. At the end of the operation the patient is removed from the mattress into his bed.

Since, during hypothermia below 32°C, the patient requires no anaesthetic other than nitrous oxide given with oxygen and curare as required, there is no danger of explosion in the cabinet. Should the patient show signs of waking during rewarming, then a little pethidine is given intravenously.

The advantages of this method are: better control of after cooling; control of postoperative haemorrhage; immediate control of the heart for massage during a period when it is particularly prone to ventricular fibrillation; closure of the thorax only when many of the changes produced by hypothermia have been reversed by the return to normal temperature. Table I shows data from a typical case.

FIG. 3
View, through transparent lid, of open thorax during rewarming.

TABLE I
Atrial septal defect. Water cooling and air rewarming.
Patient H.; female; age 16 years; weight 50 kg.

	Pre-op.	Cooling commenced 9.00 a.m.	Time pre-clamp 10.35 a. m.		Time post-clamp 10.45 a.m.	Time late closure of thorax 12.15 p.m.
Haematocrit, per cent	43	40	42		42	46
Haemoglobin, per cent	80	78	80		78	78
Alkali reserve (m.equiv)	24.5	20.6	19.3		15.1	19.7
Potassium (m.equiv)	4.7	4.3	3.7		4.2	3.0
pH	7.38(V)	7.51	7.77		7.63	7.60
Blood pressure (mm Hg)	130/80	95/60	—		—	110/70
Pulse rate/min	80	70	60		70	—
Cabinet air temperature	—	—	45°C	Clamped 6 min. 25 sec.	45°C	43°C
Water temperature	—	2°C	—		—	—
Oesoph. temperature	—	35.9°C	28.9°C		28.5°C	35°C
Rectal temperature	36.2°C	36°C	29.7°C		29.5°C	34.1°C

TECHNIQUE II

Air cooling and rewarming

Having acquired an apparatus which could also provide an atmosphere cold enough to cool patients placed inside the cabinet, the hypothermia technique could be greatly improved and simplified. The patient is anaesthetized lying upon the webbed mattress, which rests on the trolley. Induction being completed, the patient is lifted together with the mattress, which is then slid along tracks in the cabinet. The patient is supported at a height which is suitable for performing the operation. The sliding transparent lid remains withdrawn while intravenous and intra-arterial drips are prepared. Hands, feet, ears, nose, chin and male genitals are protected. The cooling machine is started and the cabinet is closed by sliding the transparent lid proximally until it contacts the transparent upright at the head end and through which anaesthetic tubes are led (fig. 4).

Thermocouples record the temperatures reached in the box and there is a thermostatically controlled switch which cuts out when the cold air

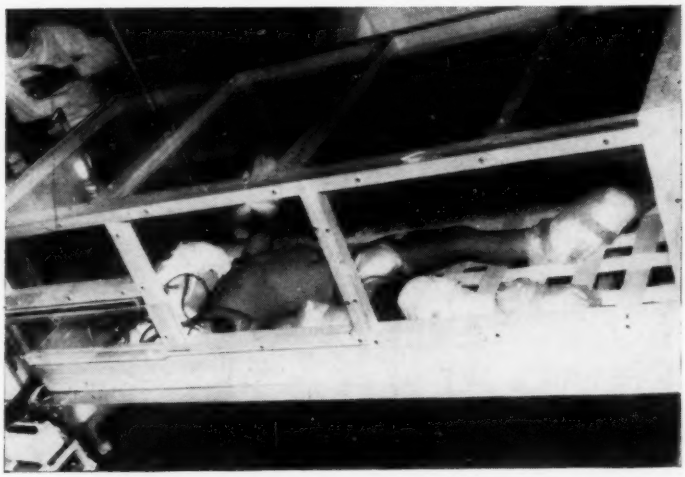

FIG. 4
Cooling in the cabinet.

circulating reaches – 5°C. Oesophageal and rectal temperatures are, of course, also recorded.

At first, a nonexplosive anaesthetic technique was used, namely nitrous oxide, oxygen, intermittent pethidine and d-tubocurarine with controlled respiration. Now nitrous oxide, oxygen ether and d-tubocurarine are used. Since a non-rebreathing valve is used, it is a simple matter to lead off the expired gases by means of tubing into a bucket with a lid placed at ground level, from which the expired gases can be sucked off by means of a suction pump which operates with air and situated outside the operating theatre. We prefer this technique at present because ether gives a more even anaesthesia and also vasodilatation which increases the speed of cooling. There is little danger of explosion since ether is discontinued at 31–32°C, the expired gases and the air inside the cabinet are sucked off continuously and also nitrogen is blown into the cabinet. It is possible that by using chlorpromazine, ether would become unnecessary and likewise these precautionary measures against explosion.

At first there is no change in body temperature just as in ice water cooling, but once it starts to fall the decrease is comparatively rapid although slower than with ice-water cooling (fig. 5). The cooling machine is shut off when the temperature is 1–2°C higher than that required for the operation. The rate of cooling then slows, but if further heat is lost too rapidly the surrounding air in the cabinet can be warmed immediately by switching on the hair dryers and the ventilating fan. There is thus complete control of the temperature which the patient reaches, and, further,

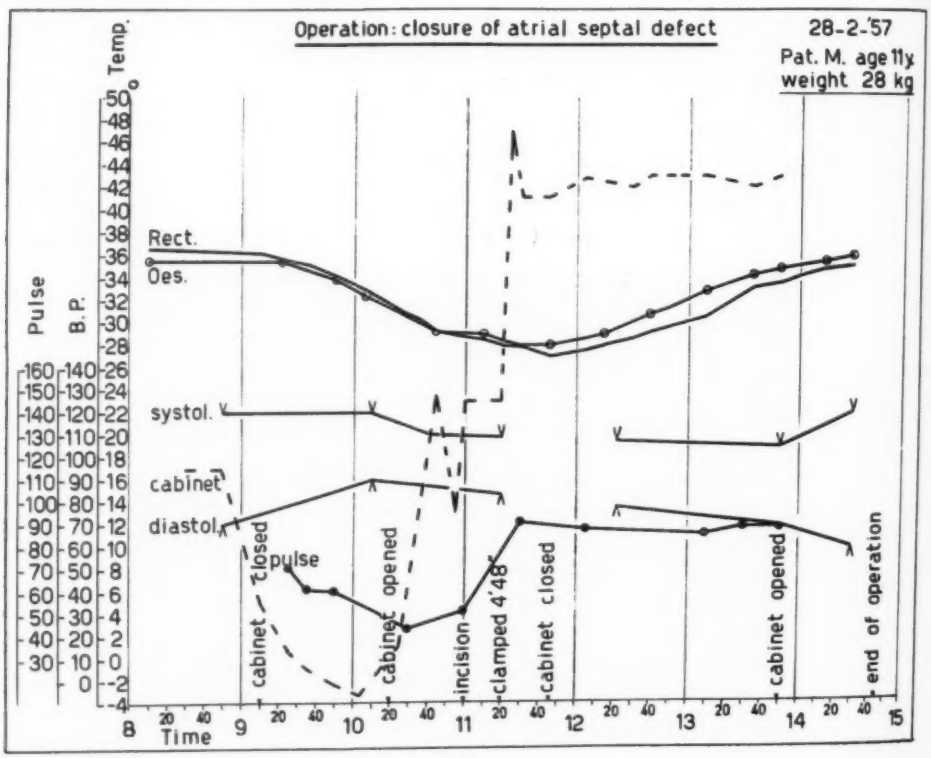

FIG. 5
Chart of air cooling and air rewarming.

TABLE II

Atrial Septal Defect. Air cooling and air rewarming.
Patient D; male; age 14 years; weight 36.5 kg May 10, 1957

	Pre-op.	Cooling commenced 9.20 a.m.	Time pre-clamp 11.40 a.m.	Clamped 5 min. 10 sec.	Time post-clamp 12.10 p.m.	Time late closure of thorax 1.15 p.m.
Haematocrit, per cent	51	49	50		42	46
Haemoglobin, per cent	100	95	101		84	95
Alkali reserve (m.equiv)	28.2	27.5	16		13.4	20.7
Potassium (m.equiv)	5.4	4.1	2.8		3.7	3.0
pH	7.41(V)	7.51	7.58		7.40	7.56
Blood pressure (mm Hg)	125/75	105/50	—		—	115/75
Pulse rate/min	76	65	55		74	78
Cabinet air temperature	—	3°C	20°C		45°C	40°C
Oesoph. temperature	—	35.4°C	28.9°C		29°C	35°C
Rectal temperature	36°C	35.6°C	28.9°C		29°C	34.1°C

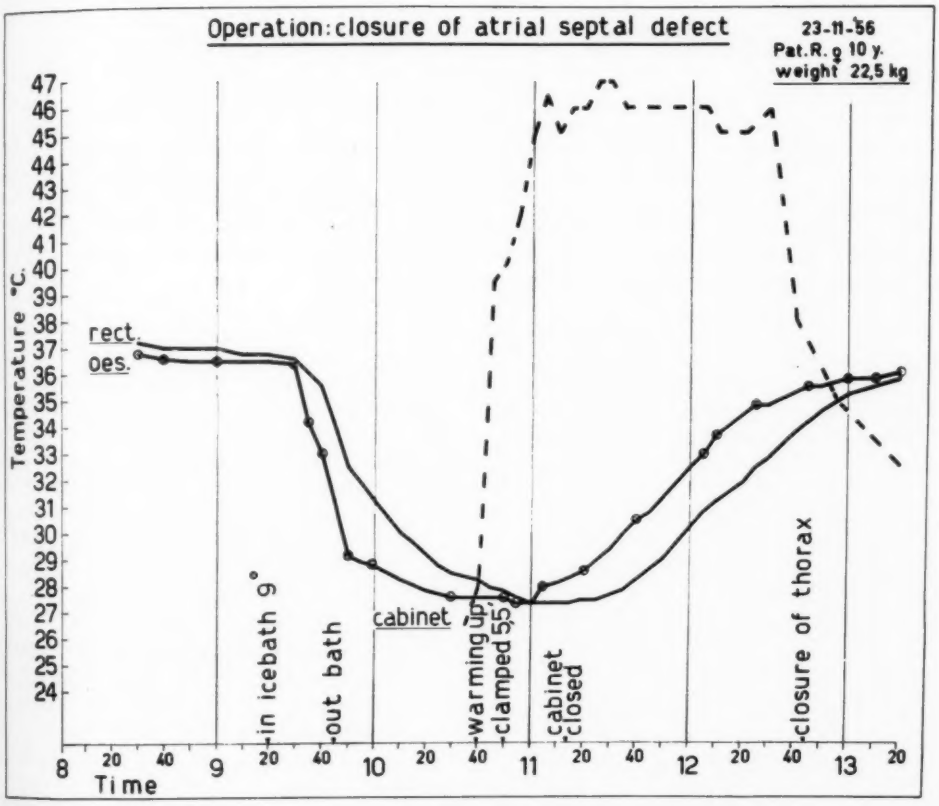

FIG. 6
Chart of water cooling and air rewarming.

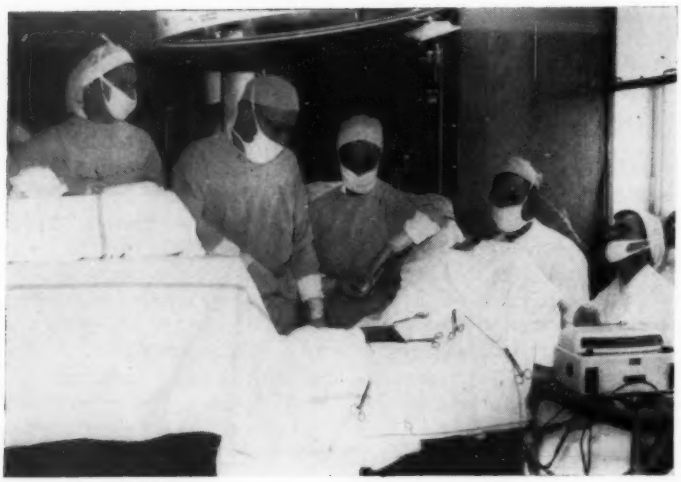

FIG. 7
The cabinet used as operating table.

by use of hot or cold air a constant temperature can be maintained for as long as may be required. This is of importance when a double heart operation is contemplated in one stage or when the intracardiac operation requires more time than can be given in one period of circulatory arrest. After waiting perhaps, if necessary, an hour after the first circulatory occlusion until biochemical values are satisfactory, a second period of circulatory arrest can be obtained and the temperature meanwhile remains constant. Table II illustrates the progress of a typical case.

CONCLUSION

The method of air cooling and rewarming has all the advantages of other methods. The only disadvantage is that it is slower and thus for the larger, heavier patients use is still made of the ice-water bath cooling method (fig. 6). Among the numerous advantages are that the temperature is completely controllable and the risk of ventricular fibrillation is, therefore, less; it is a far less cumbersome method, the patient remaining in the same place throughout the procedure; cooling can be commenced as soon as the patient has been induced; rewarming can be started immediately the intracardiac operation has been completed or even earlier; cooling is much more even, rectal and oesophageal temperatures remaining close together (figs. 5 and 6); confirmation of the diagnosis, operability and dissection can be carried out at normal temperature if desired; if required a second period of circulatory arrest can be given and the temperature can be maintained at a constant level; by applying the "late closure" technique, reversible changes are reversed before the thorax is closed and postoperative complications are, therefore, fewer; the transparent lid enables observation of the heart beat and of any bleeding during rewarming, while its removal enables rapid access should ventricular fibrillation occur. In spite of the period of time during which the thorax is open, infection has not occurred. The haemolytic changes and too rapid cooling of the heart seen during extracorporeal blood cooling do not occur with this method.

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ANAESTHESIA FOR ADENOTONSILLECTOMY*

A Critical Approach

BY

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ADENOTONSILLECTOMY is probably the commonest inpatient operation performed today and almost certainly accounts for at least half of all children exposed to the risk of anaesthesia and surgery. In 1956, in the Kingston Hospital Group, a total of 8,437 inpatient operations were performed. Of these 15.4 per cent were for adenotonsillectomy on patients aged 12 and under, representing 67.5 per cent of all operations performed on children during the year.

In view of the numerical importance of the operation, it seems desirable that the anaesthetic method commonly used for it should be critically scrutinized in the light of the changing techniques and current thought of modern anaesthesia.

For the sake of simplicity it is assumed that the commonest surgical technique is removal of the adenoids first, then dissection of the tonsils, and that the surgeon uses the Boyle-Davis gag.

THE STANDARD METHOD: A CRITICAL APPRAISAL

Premedication. Quinalbarbitone (Seconal) is given by mouth in a dose which it is hoped will ensure that the child will arrive in the operating theatre asleep and thus have no memory of the induction of anaesthesia. Here the choice of drug calls for comment. Quinalbarbitone is a drug which many prescribe and, maybe, take themselves to ensure a good night's sleep. Its time of action is about three to four hours. When used as premedication for adenotonsillectomy the child remains under its influence for some time after return to the ward, and this may well explain the delirium and postoperative restlessness associated with the drug. Its success depends on the child's co-operation in swallowing it. It is thus often impossible to produce basal narcosis by this method in the nervous and unco-operative child, the very one for whom a pleasant experience of anaesthesia is most desirable.

A further objection is that it is usually given in capsules made up to either $\frac{3}{4}$ grain (50 mg) or $1\frac{1}{2}$ grains (100 mg). In children drugs must be given according to body weight, but where they are administered in capsules precision is limited by the dose or multiples of the dose supplied by the makers of the capsules. There is also doubt as to whether the capsules dissolve satisfactorily in the alimentary tract. On two occasions, one has seen partially disintegrated capsules containing the white powder of the barbiturate in the postoperative vomitus. Had these children not vomited they would have continued to absorb their premedication for some time after the operation. As might be expected, neither child had been satisfactorily asleep in the anaesthetic room although the quinalbarbitone had been given the requisite hour and a half beforehand.

Some of these objections may be countered by the administration of the drug removed from the capsules and given in jam or orange juice with glucose. It may be given with greater precision in relation to the child's weight in the form of the Elixir. In either case the child may refuse to swallow it, as the bitter taste is difficult to disguise. Even if it is swallowed, the child may

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vomit, and it is impossible to determine the amount absorbed and how much supplementary drug should be given to replace that lost by vomiting. Assuming the drug is retained, anything taken by mouth may excite gastric secretion, and the more tasty the vehicle the greater the amount of fluid likely to be in the stomach. A fairly copious vomit is not uncommon during induction of anaesthesia following oral premedication, and the hazards of inhalation of gastric contents are too well known to require re-emphasis.

To sum up, there is much to be said for methods of premedication by other than the oral route.

Induction. The problems of induction may first stem from the possibility that the premedication may be ineffective or wrongly timed so that the child comes to the theatre awake, crying and uncooperative. Induction may be further embarrassed by excessive salivary and bronchial secretion. Let us assume, however, that the premedication leaves nothing to be desired and that the child arrives fast asleep. Anaesthesia may be induced without the child awakening with nitrous oxide or with ethyl chloride, though the latter's pungency may arouse those who are only lightly asleep. The difficulty of maintaining a clear airway then arises, for the child is undergoing the operation more often than not on account of upper respiratory obstruction. Add to this the masseteric spasm which often accompanies the use of ethyl chloride and the vomiting which may follow the premature insertion of an oral airway, and the anaesthetist's cup of agony is indeed filled to overflowing.

After induction, ether is administered until the patient is in the third plane of surgical anaesthesia. This is often time consuming, and although time should not be a primary consideration in anaesthesia and surgery, no one will deny that the temper of all concerned is improved if the list proceeds without undue delay.

It would be an advantage if the swift and smooth methods of induction of anaesthesia used in adults were to be applied to children.

Maintenance of anaesthesia. The patient has now reached the operating table, is placed in position and the surgeon inserts the Boyle-Davis gag. Some of our less experienced surgical colleagues find difficulty in inserting the gag quickly and without obstructing the patient's airway; they are often in doubt as to which size of tongue-plate is appropriate to the patient. Unless the gag is inserted quickly and the flow of nitrous oxide, oxygen and ether passed to the patient without delay through the side tube of the gag, the child is liable to recover sufficiently for the return of the pharyngeal and laryngeal reflexes. The operation is then held up while anaesthesia is deepened —not an easy matter with the gag in place. In any case, insufflation through the gag is an extremely inefficient method of administration and it is not easy to maintain a satisfactory level of anaesthesia unless the patient has been well saturated with ether in the first place. This involves a degree of intoxication beyond that which is tolerated in modern adult anaesthesia.

A further complication is that some surgeons use continuous suction through a nasopharyngeal catheter which minimizes the amount not only of blood but also of anaesthetic vapour entering the trachea.

A disturbing feature of insufflation anaesthesia for adenotonsillectomy is this possibility of aspiration of blood into the respiratory tract. Steele and Anderson (1950) aspirated the trachea in 129 children following an insufflation anaesthetic and recovered bloody secretion from 125, or 96.9 per cent. Admittedly the amounts recovered from most of the patients were small, the average amount being 3.7 ml. However, more than 5 ml were recovered from 26 patients, more than 10 ml from 8 patients, while the greatest amount recovered was 15 ml. These results give rise to fears for the safety of the tracheobronchial tree if protected by posture alone. Ballantyne and MacDermott (1953) indicate that care in maintaining the extended head posture and in turning the patient to the postoperative position without allowing the head to flex will minimize the chance of blood entering the trachea.

A further objection to insufflation anaesthesia is that the surgeon inevitably inhales quantities of ether vapour blown in his direction by the patient; one has often wondered whether he is as competent at the end of a long list as at the beginning, and it has been known for a surgeon to be obliged to interrupt his operating in order

to recover from the influence of his patient's anaesthetic.

The chief problem, then, of the maintenance phase of anaesthesia in adenotonsillectomy is the control and protection of the airway and control of the level of anaesthesia. In all other operations we jealously guard these controls; it seems illogical to abandon them in this operation.

The postoperative phase. The operation completed, the patient is returned to the ward. All are agreed on the importance of the correct position of the patient on the theatre trolley, the head down posture and skilled supervision by an experienced sister on return to bed.

Owing to the prolonged effects of the barbiturate premedication and the saturation with ether, the child remains for some time in the stage of delirium between anaesthesia and return to consciousness. Cyanotic episodes associated with retching, vomiting and laryngeal spasm are common and add to the very justifiable anxieties of the nursing staff.

After recovery of consciousness, the children appear pale and waxy, at least for the first 24 postoperative hours. Many are unco-operative and irritable. One might attribute this to the pain of the operation, but these troubles are notably absent when the patient is given an analgesic element in the premedication and if anaesthesia is maintained at a light level throughout the operation.

Is it, then, really fair that we should continue to inflict upon children an anaesthetic which we would not at the present day accept for ourselves?

MODERNIZATION OF ANAESTHESIA FOR ADENOTONSILLECTOMY

For some time the practice of paediatric anaesthesia has been gradually approximating to that for surgery in adults. This trend has been noticeable in recent papers on the subject at present under discussion (table I).

Following this trend it is suggested that children and adults may be anaesthetized by virtually identical methods. In other words a practicable technique for anaesthesia in adenotonsillectomy is:

Premedication	Papaveretum and scopolamine.
Induction	Intravenous thiopentone—suxamethonium—intubation.

TABLE I

	Techniques for adenotonsillectomy in children.				Standard anaesthetic technique for adult tonsillectomy
	Standard	Kenton and Parsons (1953)	Ballantine and Jackson (1955)	Pelmore (1955)	
Premedication	Quinalbarbitone and atropine	Quinalbarbitone, pethidine and atropine	Papaveretum and scopolamine	Papaveretum and scopolamine or quinalbarbitone and atropine	Papaveretum and scopolamine
Induction	Ethyl chloride or N_2O and O_2 deep ether	N_2O and O_2 and trichloroethylene light ether	N_2O and O_2 or thiopentone i.v. deep ether	N_2O and O_2 cyclopropane thiopentone i.v. and gallamine. Sometimes intubation	Thiopentone and suxamethonium i.v. Intubation
Maintenance	N_2O and O_2 and deep ether	N_2O and O_2 light ether + local lignocaine infiltration	N_2O and O_2 and deep ether	N_2O and O_2 and pethidine	N_2O and O_2 with trace of cyclopropane, trichloroethylene, ether, vinyl ether or halothane (Fluothane)
Method of maintenance	Insufflation	Insufflation	Insufflation,	Insufflation, sometimes endotracheal	Endotracheal

Maintenance Nitrous oxide and oxygen with a trace of cyclopropane, trichloroethylene, ether, vinyl-ether or halothane through an endotracheal tube.

Premedication. Anderson (1951) drew attention to the use of papaveretum and scopolamine as premedication in children. She pointed out that contrary to the general view they were tolerant of opiates and the dosage table suggested indicated that a 5-stone (31.6 kg) child would receive the full adult dose of 21 mg and 0.45 mg of papaveretum and scopolamine respectively. The full dosage table is given in table II. In the interests of greater precision and in order to keep dosage proportional to body weight, it is suggested that one minim (0.06 ml) of the standard papaveretum-scopolamine solution be given per 5 lb (2.7 kg) of body weight. This corresponds with Anderson's dosage for the smaller children but is a little lighter for the larger.

This premedication normally ensures that the child comes to the theatre, not necessarily asleep, but quiet, happy and sufficiently co-operative to allow the anaesthetist to perform venepuncture with ease.

There may be those who still demand that children be brought to the theatre asleep rather than risk the possibility of psychic trauma which may only be masked by papaveretum and scopolamine. As a basal narcotic, rectal thiopentone has proved very satisfactory. In a dose of 1 g. per 50 lb. (22.7 kg) it can be given with great precision in relation to body weight as a 5 per cent solution. Provided the full dose is retained it can almost be guaranteed that the child will be asleep within 10 minutes. Narcosis is at its greatest depth about 20 minutes later and if no anaesthetic were given, recovery of consciousness would be expected in about 90 minutes after the administration. Prolonged postoperative delirium is thus rarely seen. The timing of the administration must be exact and atropine must be given as soon as the child becomes drowsy.

In order to continue with the technique to be described, thiopentone induction is omitted and the endotracheal tube passed after an injection of suxamethonium only.

The disadvantages of rectal thiopentone include the possibility of a bowel action and soiling the bed linen and the extra responsibility thrown on the nursing staff by the care of the child in deepening narcosis before arrival in the theatre, though this should be no more exacting than after an effective dose of quinalbarbitone.

Induction. Thiopentone, 100 to 300 mg is

TABLE II

Modified dosage chart for premedication of children with papaveretum (Omnopon) and scopolamine (after Anderson, 1951)

1 standard ampoule contains 1/3 grain papaveretum and 1/150 grain scopolamine in 1 ml = 16.9 minims.

Body weight stone	lb	Anderson's dosage: Papaveretum (grain)	Anderson's dosage: Scopolamine (grain)	Anderson's dosage: Minims	Author's scale 1 minim/5 lb weight Minims
2	28	1/9	1/450	5.6	
	30				6
	35				7
	40				8
3	42	1/6	1/300	8.5	
	45				9
	50				10
	55				11
4	56	1/4	1/200	12.7	
	60				12
	65				13
5	70	1/3	1/150	16.9	14
	75				15
	80				16
	85				17

given intravenously. The readiness with which one may induce anaesthesia with thiopentone depends on the availability of a vein and the co-operation of the patient. In children, a vein can usually be found on the back of the hand, and the nurse who comes to the theatre with the child can help by grasping the forearm gently but firmly and flexing and extending the wrist for some little time before anaesthesia is induced. Following papaveretum-scopolamine premedication, there is seldom any show of fear on the part of the patient (figs. 1 and 2). The behaviour of a series of 100 children following venepuncture is given in table III.

TABLE III
Response of 100 children to venepuncture following papaveretum-scopolamine premedication

No response	66
Winced, but remained cheerful	13
Audible response, whimpered or sharp intake of breath	13
Started crying but did not prevent venepuncture	7
Unco-operative, attempt at venepuncture abandoned	1
	100

The induction dose of thiopentone is followed by suxamethonium 15 to 25 mg, and after relaxation has become complete the trachea is intubated through the mouth. It is here that the method varies from normal adult practice, in that the necessity for removing the adenoids and the possibility of trauma to the narrow nasal air passages in children preclude intubation through the nose. The endotracheal tube should be fitted with a "nasal" connecting piece and should be attached to the catheter mount before intubation. The whole assembly is fixed with adhesive tape so that the tube emerges from the right side of the mouth and the catheter mount lies on the patient's chin (fig. 3).

FIG. 1

FIG. 2

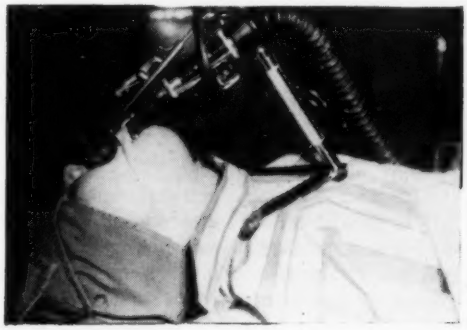

FIG. 3

Maintenance. Anaesthesia is maintained both before and after resumption of spontaneous respiration with nitrous oxide and oxygen with a trace of cyclopropane or a volatile agent. Recently traces of halothane (Fluothane) have been found to be satisfactory supplement to nitrous oxide and oxygen, enabling the patient to remain at a very light level of narcosis without coughing on the tube. In the operating theatre the Boyle-Davis gag is inserted by the surgeon. Timing is important so that the gag is placed in position while the mas-

seters are still relaxed by the suxamethonium given for intubation. The catheter mount connecting the tube to the anaesthetic machine should be fixed alongside the upright part of the Boyle-Davis gag so that the tube lies flat along the floor of the mouth (fig 3). The adenoids and left tonsil are removed and all bleeding arrested in the left tonsillar fossa. The tube is then transferred to the left side of the mouth by temporarily detaching the catheter mount from the expiratory valve, cutting the adhesive tape and carefully moving the tube so that it does not slip out of the trachea (fig. 4). The right tonsil is then removed, bleeding arrested and the operation completed.

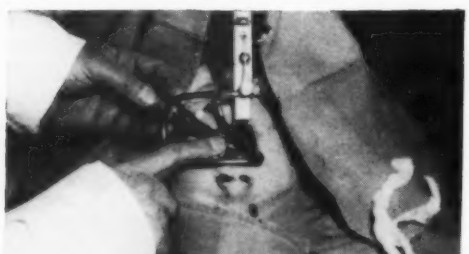

FIG. 4

This method ensures a pleasant, rapid induction for the patient and a clear airway at a light level of anaesthesia throughout the operation. The presence of the tube in the larynx reduces the chance of aspiration of blood and, if desired, a small pack may be placed round the tube for greater safety. Surgical access is good and is not seriously limited by the presence of the tube in the mouth; indeed on many occasions the right tonsil has been removed without the tube having to be transferred to the left side of the mouth. The surgeon does not inhale quantities of ether vapour.

The postoperative phase. The child recovers consciousness rapidly and in most cases remains quiet under the analgesia endowed by the premedication; he can sometimes even be induced to smile very shortly after the operation. He is rosy cheeked and does not show the waxy pallor well recognized as the sequel of deep ether narcosis. His wellbeing is reflected in his appetite for breakfast the following morning.

It may be objected that the tube passed through the mouth inevitably occupies part of the small operating space available to the surgeon particularly during the digital examination of the nasopharynx. To obviate this objection the tube can be accommodated between the tongue and a specially designed tongue-plate. Such an instrument was described by Humby and Hawksley (1943) for cleft palate surgery, while Monro (1948) reported on such an instrument specially made for use in tonsillectomy. A simple instrument has been made by cutting a slot down the centre of a standard Boyle-Davis tongue-plate, bevelling the edges of the slot on the lingual surface and fitting a small metal bridge at the distal end to prevent the tube wedging in the slot (fig. 5; Doughty, 1957). The tube can be accommodated out of sight of the surgeon under

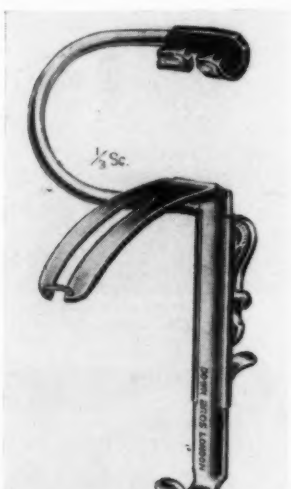

FIG. 5

the tongue plate without obstruction to the airway. It is made in three sizes, the largest being suitable for adults, in whom a satisfactory anaesthetic for tonsillectomy may be given by this means and a nasal intubation avoided (fig. 6).

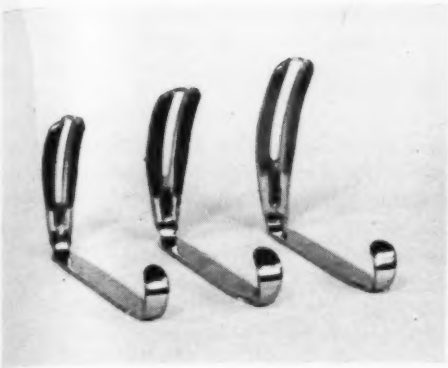

FIG. 6

In using the gag with the slotted tongue plate, anaesthesia is induced as before and the tube passed orally, but instead of its being fixed on the right side of the mouth, it is placed centrally. It should not only be fixed centrally over the lips and teeth but it should be seen that the tongue lies symmetrically under the tube within the mouth. The surgeon then passes the gag with the slotted tongue plate into the mouth taking care that the central fixation of the tube is not disturbed. This takes some practice and the extra trouble may not be tolerated by the less patient surgeon. It is important that too small a size of tongue plate should not be used, as the tube will become obstructed as it curves over the bulge of the tongue beyond the end of the tongue plate. The use of this device avoids the need for changing the tube from one side to the other during the course of the operation and it enables both tonsillar beds to be under inspection simultaneously at the end of the operation.

In short, then, it is suggested that a technique widely used for adult tonsillectomy requires only slight modification to give very satisfactory anaesthesia for adenotonsillectomy in children.

DISCUSSION

The desirability of intubating children for adenotonsillectomy is controversial. Magill (1948) has expressed what may be the majority view as follows: " The necessity for intubation for the dissection of tonsils in children is open to question. Many experienced surgeons and anaesthetists will agree that a capable anaesthetist should be able to provide adequate facilities for a capable surgeon and protection for the patient without intubation." Baron and Kohlmoos (1951) state: " It is difficult to understand why in children endotracheal anaesthesia should be used for adenotonsillectomy. Anaesthetists have argued that they protect the patients' airway from the blood overflow that occurs in the hands of certain surgeons. This may be so in some instances, but it does not seem reasonable that an endotracheal tube should be used as a substitute for good surgery." It will be noted that both authorities stress that intubation should be unnecessary with capable surgery, yet it must be admitted that the tonsil session provides experience to many a novice surgeon and anaesthetist.

In considering the question one must assess the advantages and then count the cost. Intubation enables a rapid induction to be followed by maintenance at a light level of anaesthesia throughout the operation, with control of the airway, protection of the tracheobronchial tree from inspired blood and protection of the surgeon from the anaesthetic vapours. The patient, having been only lightly anaesthetized, recovers consciousness very rapidly, gives less trouble to the nursing staff and suffers negligible constitutional disturbance.

The cost of intubation is firstly the increase in complexity of anaesthetic technique. We accept this in adults, so why not in children? Of itself intubation does not guarantee a perfect airway. The problems of too long or too short a tube, kinking or compression of the tube may arise, but the prevention or solution of these difficulties is well within the competence of the average anaesthetist. Trauma inflicted by the laryngoscope is a possibility, but the perfect conditions provided by suxamethonium for intubation should make trauma inexcusable. We have progressed since 1930 when Moss declared: " ploughing up the pharynx with a laryngoscope in an attempt to dig out an epiglottis from a pool of bloody mucus is one of the least inspiring sights of modern anaesthesia."

There remains for consideration the danger of the immediate and late sequelae of damage to the

vocal cords and trachea. Laryngeal granulomata rarely occur in children, but glottic oedema and membraneous laryngotracheitis with sloughing of the mucous membrane may be fatal. Many of the cases reported may be attributed to a traumatic intubation, unsuitable lubricant on the tube, failure to suppress the cough reflex after intubation, too large a tube, or the presence of the tube in the trachea for an excessively long time. In this connection, Pender (1954) compared the incidence of the complications of intubation after neurosurgical operations with an average time of 138 minutes and after adenotonsillectomy with an average time of 41 minutes. In the neurosurgical group the incidence was 5.4 per cent of 334 operations, while in the tonsil group the incidence was only 0.3 per cent of 1,050 operations.

Collins and Granatelli (1956) recorded hoarseness and laryngeal stridor following intubation for tonsillectomy in 19 out of 500 cases—3.8 per cent. In all these there was evidence that the intubation had been difficult. The same authors, however, report similar symptoms in 21 out of 200 patients—10.5 per cent—who were given an insufflation anaesthetic without intubation. This lends substance to the view that the forceful blast of cold ether vapour impinging upon the larynx may be no less responsible for postoperative discomfort than a gentle intubation.

These figures are from American papers and there exist many instances in other contexts where transatlantic experiences do not accord with those in this country.

CONCLUSION

A critical approach to established methods of anaesthesia for adenotonsillectomy is long overdue and is worthy of the attention of anaesthetists.

Collins and Granatelli (1956) write: "The most neglected of anaesthetic procedures is that for tonsillectomy. The anaesthesia is usually considered to be too minor and too simple to deserve the attention of the expert. It is relegated to the novice and conditions are permitted that would not be tolerated in any adult patient. From the moment the child enters hospital he is shocked, psychologically, physiologically and pharmacologically."

These are strong words with which one may or may not agree. That many anaesthetists fight shy of the tonsil list is unfortunately true. It is possible that their aesthetic sense is offended by the outmoded and inelegant methods forced on them by the conservatism of their surgical colleagues. The removal of tonsils and adenoids is usually a child's first experience of hospital treatment. He must be conceded the same right as his parents to the skilled application of the methods of modern anaesthesia.

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CONTROLLED RESPIRATION IN NEUROSURGERY*

BY

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A GREAT deal has been written about the requirements of neurosurgical anaesthesia, but little about the use of controlled respiration for these cases. It appears, however, that the use of controlled respiration in neurosurgery has spread throughout various centres in Australia.

It is intended here to describe a technique for neurosurgical anaesthesia using controlled positive and negative pressure respiration.

Prior to April 1956, an open technique was invariably used at St. Vincent's Hospital, Melbourne, which appeared to give better operating conditions than controlled respiration with intermittent positive pressure. However, since obtaining a Harrington-James respirator an increasing number of cases has been done with controlled positive and negative pressure, until the present when the majority of cases are anaesthetized by this method. It is considered that a soft brain and good operating conditions are more consistently achieved.

TECHNIQUE

Premedication.

This depends on the physical state of the patient. Papaveretum and scopolamine are used for fit adults with a normal intracranial pressure. Graded doses of the same drugs (or occasionally pethidine is substituted for papaveretum) are given even in the presence of a raised intracranial pressure after seeing and assessing the patient. Atropine alone is given for comatose patients.

Morphine causes respiratory depression, but does not appear to increase intracranial tension in the presence of adequate pulmonary ventilation. If no analgesic is included in the premedication either a larger dose of relaxant is needed to settle the patient, or intravenous pethidine is needed during the anaesthetic.

Induction.

Unless the patient is comatose, anaesthesia is induced with sodium thiopentone given in 2.5 per cent solution and followed by 50–100 mg of suxamethonium. A comatose patient is not given thiopentone and suxamethonium only if the laryngeal reflexes are present. The patient's lungs are ventilated with oxygen and after spraying the larynx and trachea with 4 per cent lignocaine, intubated with a number 9 or 10 short bevel cuffed Magill's tube. A pharyngeal airway is also inserted and all connections are checked and firmly strapped in position.

The patient is now ventilated with nitrous oxide (2 litres) and oxygen (1 litre) in a closed circuit with circle absorption. When respiration returns d-tubocurarine (30 mg) is given, and when the patient is settled he is taken into the operating theatre and put into position. Usually another 10 mg of d-tubocurarine is needed during the procedure. In some patients, especially in those undergoing laminectomy, gallamine has been used. In order to ensure that the endotracheal tube is unobstructed, it is advisable to use tracheal suction after positioning.

The rebreathing bag is now detached and the circuit connected to the Harrington-James respirator. The pulmonary ventilation and the degree of positive pressure are adjusted to the individual patient.

An intravenous saline drip is set up in the leg and blood is replaced as it is lost.

Harrington-James Respirator.

The ventilation rate is fixed at 20 per minute. In this apparatus a concertina bag is connected via a gear link system to a sparkless electric motor.

* From a paper read to the Australian Society of Anaesthetists, Adelaide, May 1, 1957.

A crank lowers and raises the link which alters the volume drawn in and out of the bag and, therefore, the pulmonary ventilation. By altering the tension on an ordinary expiratory valve, variations in the negative pressure can be obtained. Decreasing the tension increases the negative pressure.

When adjusting the machine, (1) the endotracheal tube must not be obstructed, (2) the patient must be fully curarized, (3) total ventilation must be adequate for the individual patient. In practice it is aimed to achieve hyperventilation and (4) the amount of positive and negative pressure is adjusted usually to +8, −5 ml of water.

Maintenance

Anaesthesia is maintained with nitrous oxide and oxygen 2 litres—1 litre and intermittent doses of relaxant. It is essential to keep careful records and note the time/dose relationship of relaxant, until the patients' response to the drug can be adequately gauged. During the first two hours approximately 10 mg of d-tubocurarine will be needed every half-hour.

A patient who continues to breathe against the machine and requires abnormally large doses of relaxant and has, as a result, a "tight" brain, either has an obstructed airway or is being underventilated, both of which lead to a raised carbon dioxide tension in the blood.

If pulmonary ventilation is adequate decurarization is most often shown by movements of fingers and toes and seldom by coughing, bucking or attempts to breathe against the machine.

The average case which has received adequate premedication does not require further doses of thiopentone or intravenous analgesic after induction.

The soda lime must be changed at least every two hours. A careful attention to the details of neurosurgical anaesthetic technique is essential, particularly as regards posture. A negative pressure phase in the respiration will not compensate for an obstructed airway.

Emergence.

At the completion of operation atropine 1.3 mg is given and the carbon dioxide absorber turned off until spontaneous respiration returns. After a long operation with a prolonged period of hyperventilation it appears better to let the patient breathe spontaneously for ten minutes before giving neostigmine so that the respiratory centre can regain its normal rhythm. The pharynx and, if necessary, the larynx are sucked out; atropine followed by neostigmine (2.5 mg) are given and the endotracheal tube removed.

Most patients are awake and responding before leaving the theatre and the anaesthetist's neurological examination can be carried out.

DISCUSSION

During two years at St. Vincent's Hospital, Melbourne, approximately half the anaesthetics for both routine and emergency operations in the neurosurgical department have been administered by the author. During the first twelve months open circuit was used and during the last twelve months controlled respiration with positive and negative pressure. Detailed records are available of only 100 anaesthetics—72 craniotomies and 28 spinal operations—far too small a number for statistical purposes. It is, nevertheless, a strong clinical impression that we are obtaining better operating conditions with the controlled respiration technique, an opinion shared by the other anaesthetist in the unit.

The demands of neurosurgery vary. This technique cannot be forced on a surgeon who relies on changes in respiration to denote damage to the medulla, hypothalamus, pituitary or third ventricle, and who is worried about the dangers of retraction anaemia in a soft brain. Others, however, find good operating conditions outweigh these disadvantages.

After preliminary tentative trials, gradually the neurosurgeons were completely convinced and now prefer this technique.

The beneficial effects of controlled positive and negative pressure respiration in neurosurgery are mainly two:

Adequate pulmonary ventilation or hyperventilation with the maintenance of the blood carbon dioxide tension at normal or below normal levels despite the use of hypnotic and analgesic drugs. With spontaneous respiration, it is extremely

difficult to avoid respiratory depression and, therefore, some rise in carbon dioxide tension. As cerebral vascular congestion is related to the increased tension of carbon dioxide in the arterial blood, a normal or lowered tension should reduce or prevent it.

The phase of subatmospheric pressure greatly reduces venous bleeding. Controlled respiration with intermittent positive pressure will maintain a normal carbon dioxide tension, but with the loss of negative pressure in the thorax there is an increase in venous pressure which is reflected back to the brain with a considerable increase in venous oozing which would greatly impede the surgeon.

The negative phase in the respiratory cycle compensates for this and lowers the venous pressure and greatly decreases venous oozing. In some cases the ebb and flow of blood in the diploic veins has been seen with a decrease in bleeding during the negative phase of the cycle.

The negative phase has considerable effect on the tension of the brain and the surgeon frequently remarks on the slackness of the brain.

Hypotension.

Hypotension is very rarely needed with this technique as such good operating conditions are obtained. Trimetaphan is reserved for vascular surgery where a high arterial tension makes the operation dangerous.

When induced hypothermia has been used in Melbourne, shivering has been controlled with curare and, therefore, controlled respiration has been essential.

In summary the advantages claimed for this method are:

(1) Induction is both quicker and easier than with an open circuit. Posturing is more easily done without fear of coughing or bucking.

(2) The decrease in vital capacity and, therefore, in pulmonary ventilation which occurs when the patient is breathing spontaneously in the lateral and prone positions is easily compensated for. This is particularly useful in the prone position as in chordotomies and laminectomies for malignant disease. In cervical sympathectomies it is possible temporarily to decrease the ventilation if the movement of the pleura worries the surgeon and there is, of course, complete control of the respiration if the pleura is punctured.

(3) Coughing is under absolute control—a a requisite for neurosurgery. A much smoother anaesthetic without any straining and rise in venous pressure is obtained.

(4) The technique can be used for the patient in the sitting position where chlorpromazine is contra-indicated.

(5) The bronchitic, emphysematous, heavy smoking patient who is very difficult to anaesthetize on an open circuit is easily handled.

(6) Good operating conditions are more consistently obtained.

(7) The patients are awake more quickly.

(8) It is an impression that blood loss, particularly in laminectomies, is less.

(9) The technique is suitable for the aged.

(10) Owing to its simplicity and reliability, new registrars learn the technique rapidly.

The disadvantages of the procedure are:

(1) Possibility of prolonged curarization following long operations or due to sensitivity to relaxants.

(2) Interference with the respiratory centre at operation is masked, e.g. in posterior fossa operations or pituitary tumours.

(3) It is not suitable for children with the equipment at present available.

(4) If the ventilation for any reason is inadequate very bad operating conditions will result.

(5) Occasionally the blood pressure drops following the administration of d-tubocurarine.

(6) Excessive bleeding from the skin flaps may occur while sewing up, due to the rise in carbon dioxide tension when the soda lime is turned off, and the patient starts to breathe spontaneously.

CONCLUSION

In conclusion one must remember that neurosurgical anaesthesia is the most humbling of all. Any physiological change is transmitted immediately to the surgeon and many factors can produce a tight brain.

It is impossible to say that this method is better than spontaneous respiration and equally good

operating conditions are produced with perfect open circuit anaesthesia. However, it is not always possible to give a perfect anaesthetic on an open circuit and there are a percentage of patients who are not suitable for this method. It would seem that good anaesthetics are more consistently given with this method and the neurosurgeons appreciate the " slack " brain and good operating conditions.

SUMMARY

A technique of anaesthesia for neurosurgical cases is described in which the patient is fully curarized and pulmonary ventilation achieved by intermittent positive pressure respiration using a subatmospheric pressure in the expiratory phase. The Harrington-James respirator is employed.

The apparent advantages and disadvantages of the technique are discussed.

BOOK REVIEW

Muscle Relaxants in Anesthesiology. By Francis F. Foldes, M.D. Published by Charles C. Thomas, Springfield, Illinois. Pp. 210; illustrated. Price 42*s*.

It is perhaps surprising that there has not been a monograph on the relaxant drugs since the admirable work of McIntyre on curare in 1951. The volume under review produced by Dr. Francis Foldes should therefore find a ready welcome. It is one of the American Lecture Series and, as can be seen from the above details, it is a larger book than many of its forerunners. Information is here in plenty.

There are 414 references in the excellent bibliography at the end of the book, and it is gratifying indeed to find that work outside the United States is given due credit.

Fifty-one pages which form part one are devoted to fundamental considerations concerning the mode of action and pharmacology of these drugs. The arrangement of the former is clear, and here the author has made a useful contribution by his helpful classification of these drugs into depolarizers and nondepolarizers, thus avoiding the ambiguity attendant on the term " competition block ", and also the unnecessary confusion of Bovet's " Lepto " and " Pachy " terminology.

What the author has not done is to attempt any critical assessment of the abundance of work that has been carried out on this subject and on the pharmacology of these drugs. Valuable contributions backed by sound experimentation are not markedly differentiated from work founded on a less firm basis.

The next section of the book, of some 100 pages, goes under the title of " Clinical Uses ". Techniques are given in detail—almost minute detail—and the pros and cons of controlled and assisted respiration, the uses of antidotes, as well as varying sensitivity to the action of muscle relaxant drugs, are discussed. In general, however, it must be confessed that many British anaesthetists will be left wondering at an approach in the clinical field so obviously different from theirs. The emphasis is very much on the use of drugs depressant to the central nervous system helped out by relaxants. It is interesting to find a description of the author's technique using supplementation of anaesthesia by central nervous depressant drugs combined with their antagonists in attempt to avoid their respiratory depressant effects. A number of the opinions expressed in this section of the book are not likely to find ready acceptance on this side of the Atlantic—but that does not necessarily mean that they have been proved wrong. That would call for yet another book.

T. Cecil Gray

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CONVULSION DURING ETHER ANAESTHESIA

A Case Report

BY

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A five-year-old girl was admitted to Hammersmith Hospital with a diagnosis of a perforated appendix. Her mother stated that she had complained of pain in the R.I.F. for 12 hours prior to admission, that during that time she had vomited periodically and was "breathing very fast." The pain had become severe in the evening and she was brought up to the Casualty Department.

Physical examination revealed a well developed child in slight distress and looking very toxic. Her temperature was 102.6,°F pulse rate 140 min, respiration rate 30 min. There was no history of previous illness or fits.

It was decided to operate and premedication of atropine (0.6 mg) was given 40 minutes before operation. The temperature in the operating theatre was 86°F and outside there was a thunderstorm. Anaesthesia was induced with N_2O and O_2 at 2 a.m., ether being added slowly in a semiclosed circuit. On establishing second plane anaesthesia an intravenous drip of 5 per cent Dextrose was set up and the skin incision made 15 minutes later. At 2.30 a.m. the peritoneum was opened and free pus found. At the time the peritoneum was lifted to open, very mild twitching of the eyelids and facial muscles was noted; these rapidly spread to the trunk and limbs, followed by generalized convulsions. The ether was turned off at once, the surgeon stopped his manipulations, the bag on the anaesthetic machine was emptied and pure oxygen was administered. At the same time 3 mg of d-tubocurarine were put into the drip and within three minutes all convulsive movements ceased. The respiratory movements became slightly depressed, and so respiration was assisted. Anaesthesia was maintained on a 5:2 N_2O-O_2 mixture and assisted respiration continued while the surgeon removed the perforated appendix and closed the abdomen 25 minutes later. Respiratory exchange was adequate by this time. Pharyngeal toilet was carried out and much thick mucus was removed. It was considered advisable to keep the child under further observation and she was kept in the operating theatre.

At 3.10 a.m. (15 minutes after completion of surgery) she was about to be returned to the ward when slight clonic movements of the arms and legs were noted: these gradually became more pronounced; the reflexes were hypertonic, opisthotonos was present to such an extent that a closed fist could be placed easily under the arched back. At the first of these signs oxygen and a little CO_2 (300 ml for 1 min) was given, the head of the table raised and 1 ml of 2½ per cent thiopentone was injected into the drip. The CO_2 was given because it was thought that with the assisted respiration her alveolar CO_2 content might be low.

These measures had no effect on the carpopedal spasm and so a further 2 ml of thiopentone with 0.5 mg of d-tubocurarine were given; this reduced the movements. The child felt excessively hot and sponging with ice cold water was carried out for 20 minutes to the upper and lower limbs, axillae and groins. Oxygen administration was continued.

Pronounced movements started again at about 3.50 a.m. and this time 4 ml of calcium gluconate (5 per cent) were given intravenously. There was no effect from this but another 25 mg of thiopentone caused the movements to cease. This time she remained quiet for about 45 minutes, and when movements did return they were much less severe. A final dose of 2 ml of calcium gluconate was given and at 5.30 a.m. she opened her eyes and soon after that began to cry.

She was sent back to the ward at 6 a.m. and

was fully conscious by 9 a.m. and able to respond to questions. Apart from slight (? voluntary) shaking of the head, no other movements were noted and she appeared quite normal, subsequently she made an uneventful recovery and was discharged from the hospital ten days later.

DISCUSSION

From this case report it will be seen that quite a number of the so-called predisposing factors were present, namely: pyrexial patient, hot theatre, humid atmosphere, sepsis (pus in peritoneum), vomiting (? hypocalcaemia), and fast respirations (hypocarbia), atropine as premedication (causing a further rise in temperature and preventing sweating), and finally ether as an anaesthetic agent. One might say that the stage was set for convulsions. One or two points should be noted:

(1) The character of the first convulsion was different from the subsequent ones, i.e. it was a convulsion in which the movements had no particular characteristics, whereas the latter ones were tetanic like with carpopedal spasm, opisthotonos and plantar flexion.

(2) At the start of the operation the pupils were medium dilated and slowly returned to normal by the time the skin was sutured. Over the next two hours they gradually enlarged and remained almost fully dilated for some hours after return to the ward. They reacted very sluggishly to light.

(3) The convlusion occurred at the same time as the pulling of the peritoneum—this may have been coincidence.

(4) The dose of calcium gluconate could have been larger.

ACKNOWLEDGMENT

My thanks are due to Mr. Selwyn Taylor for permission to publish the case.

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THE USE OF AN INFLATABLE CUIRASS IN ENDOSCOPY

BY

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To share the patient's airway with the surgeon, in the absence of an endotracheal tube, often presents the anaesthetist with additions to the normal problem, in such circumstances, of adequate pulmonary ventilation. In no cases is this more evident than during laryngoscopy or bronchoscopy under general anaesthesia. Complete relaxation with really quiet breathing may not be difficult to obtain, but it is far from easy to maintain this state if the examination is continued for some time. The combined use of thiopentone and suxamethonium, after local analgesia has been instituted in the larynx and trachea, provides excellent conditions for these examinations. Intermittent injections of either drug may be required if the procedure is prolonged, and fluctuations may occur in the patient's condition. The uneven anaesthesia results in the species of " intermittent bronchoscopy " already deprecated by Macintosh (1954.) It causes also interruptions in the surgeon's work and anxiety to the anaesthetist. Various methods of overcoming the problem of ventilation and oxygenation have been described in recent years. Churchill-Davidson (1952a) described the occasional insufflation of oxygen down the bronchoscope after insertion into its lumen of a close-fitting Magill's tube, and repeated the advice at a later date (1952b) when he had employed suxamethonium instead of gallamine triethiodide as the relaxing agent. Macintosh (1954), already quoted, called in the help of topical analgesia. Cheatle and Chambers (1955) described the use of a fine Portex tube passed into the trachea alongside the bronchoscope. Through this fine tube oxygen was delivered during the anaesthesia and their paper includes figures for pO_2 and pCO_2 in the blood. Buck (1955) wrote confirming this technique and stressing the importance of high flow rates to avoid CO_2 accumulation. The earliest available reference to the use of a respirator in anaesthesia for bronchoscopy was found in an article by Toker (1955). He reported the use of a Kifa respirator applied to the chest, after the patient had been anaesthetized with thiopentone and relaxed to apnoea with suxamethonium.

The application of a cuirass respirator for endoscopy has also been described by Green and Coleman (1955) and by Bayuk (1955). These observers stress the value of such an apparatus for maintenance of ventilation during anaesthesia and relaxation. In the former report a negative pressure cuirass respirator of the Monaghan type was employed. This consists of a pump unit, twelve graded sizes of chest shells and possibly a battery. The apparatus used by Bayuk was an Emerson chest respirator and includes also a selection of shells for application to the chest.

The use of a cuirass to produce adequate movement in the chest thus seems to offer a satisfactory solution to the problem encountered in endoscopy. The apparatus described in the papers mentioned is mildly elaborate and includes an expensive machine. The inflatable cuirass described here is exceedingly simple, quite inexpensive and has proved very efficient on the occasions when it has been in use. Its construction is based on the sphygmomanometer cuff—an enlarged rubber bag is enclosed in a light cover to which are sewn two web straps with appropriate buckles which allow of a certain amount of adjustment to fit the patient's chest. The cuff extends from a little below the nipple line to a few inches below the xiphisternum, and from the posterior axillary line on one side to the same line on the other when it is applied to the front of the chest in an average adult. Two or three different sizes have been made and these can be adjusted to fit adequately on

FIG. 1

patients varying from a small child to a large and bulky adult. From the lower side of the cuff, a wide bore, short rubber tube projects. It is braced with a metal sleeve into which fits the facepiece mount of a Boyle's anaesthetic apparatus. The back of the cuirass is a simple rectangle of rubber and light canvas from which the web straps extend. The photographs reproduced here show clearly the construction of the cuirass (fig. 1) and its application to the chest and attachment to the Boyle's machine (fig. 2).

It is desirable to produce a mildly sedated patient who can be readily translated into a light, controllable plane of anaesthesia—who will be fully relaxed during endoscopy, and who will quickly regain a return of reflexes and even consciousness at the close of the procedure. Adequate oxygenation must be ensured during apnoea or shallow breathing, but as these examinations are usually comparatively brief, development of respiratory acidosis can be largely ignored.

TECHNIQUE

The patient is premedicated with atropine sulphate 0.6 mg and papaveretum 20 mg one hour before the time chosen for the examination. On arrival in the theatre, the patient is placed upon the operating table and the inflatable cuirass is adjusted on the chest. It should be strapped in position firmly but not tightly and should give the patient a feeling of support. The upper border should lie below the nipple line and the lower border a few inches below the xiphisternum. From side to side it should extend from the posterior axillary line on one side to the same point on the other. Varying sizes of patients make it impossible to achieve this position exactly, of course, but the different sizes of cuirass will allow of an adequate approximation in each instance. It is suggested that the method is applicable to infants to whose chest can be applied an ordinary sphygmomanometer cuff.

Anaesthesia is now induced with thiopentone (maximum initial dosage 500 mg) and this is followed by the intravenous injection of an appropriate dose of suxamethonium which has been diluted to a strength 100 mg in 10 ml of sterile water. Such a dilution allows of a more accurate estimate of dosage and may help to diminish the postoperative muscular pains of which many patients complain after the use of this drug. Whenever relaxation supervenes, a few inhalations of oxygen are given by application of a facepiece and manual pressure on the rebreathing bag of a Boyle's apparatus. If the larynx and trachea have not been prepared with a topical analgesic beforehand, they are now sprayed under direct vision

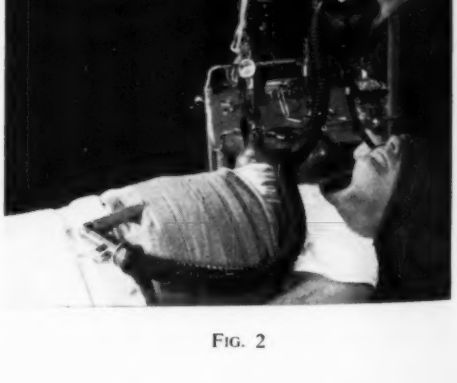

FIG. 2

with 4 per cent lignocaine with adrenaline and the surgeon can begin his examination on a fully relaxed patient. The topical analgesia is valuable in diminishing reflex responses, and in the prevention of such responses at the close of the procedure when the bronchoscope or laryngoscope is withdrawn.

Immediately following the inflation of the lungs with oxygen, the facepiece is removed and its mount is now attached to the sleeve in the rubber tube connected to the cuirass. The cuirass and rebreathing bag are filled from the apparatus to a comfortable tightness, the gases are shut off, and firm manual intermittent pressure on the rebreathing bag will produce the necessary rhythmic inflation and deflation of the cuirass with a corresponding effect on the chest. A separate small flow of oxygen (5 or 6 litres per minute) is now led into the aspirating tube of the bronchoscope and the movement of this oxygen in the depths of the bronchial tree will maintain the patient in the desirable pink colour of adequate oxygenation. In laryngoscopy, the oxygen is similarly led to the back of the nasopharynx by means of a fine nasal endotracheal tube which has been cut appropriately short. Figure 3 shows the result of a continuous estimation of oxygen saturation of the blood carried out on a patient undergoing a bronchoscopic examination which lasted for 25 minutes from the time of induction until the completion of the procedure. It can be seen that there was a fall to 80 per cent momentarily during induction and to 82 per cent while the bronchoscope was deeply situated for a short period in the left main bronchus. During the rest of the examination O_2 saturation remained at or above 90 per cent.

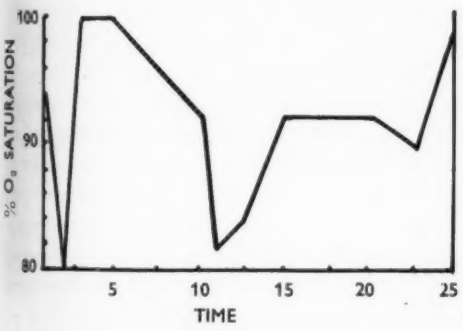

FIG. 3

Following the injection of the initial dose of suxamethonium, the needle is maintained in the vein and supplementary doses of this drug or of thiopentone can be given. The return of respiration can be readily appreciated by the hand holding the rebreathing bag. It is only occasionally necessary in longer examinations to supplement the initial dose of thiopentone. The use of a Gordh or Mitchell needle is an acceptable refinement.

At the close of the examination or biopsy, the airway is aspirated, the endoscopic instrument withdrawn and the patient is usually now breathing spontaneously and only lightly asleep. Reversion to the facepiece or continuation for a few moments with the cuirass will control the patient whose ventilation is considered to be still inadequate.

RESULTS

The method has now been used very successfully in 30 cases which include 15 laryngoscopies and 15 bronchoscopies. The ages of the patients range from 6 to 67 years and have included heavy robust types as well as frail and delicate subjects. In only two cases has complete success not been achieved. This was due entirely to a failure to fit the cuirass properly to the chest in especially the very adipose female with bulky breasts. The fatty tissue appeared to cushion the effects of the cuirass which should clearly have been applied below them at a lower level.

The duration of the examinations has varied from a minute or two up to fifteen or twenty minutes and the patients have been maintained in full relaxation, largely apnoeic and well oxygenated throughout. Two cases might be briefly cited as illustrative of the benefits conferred.

(1) Male (47). Large, 16 stone (101 kg); large teeth, massive jaw; biopsy of vocal cord tumour; duration 15 minutes; thiopentone 850 mg; suxamethonium 180 mg. This case would have been impossible without full relaxation and in the event, he gave no trouble at all.

(2) Male (58). Emphysematous; bronchoscopy; previously failed on account of spasm and cyanosis. Completed successfully with aid of the cuirass at a second attempt.

DISCUSSION

The use of this simple device has removed almost all the anxiety from anaesthesia for endoscopy. The patient can be maintained for considerable periods in an adequate state of oxygenation and no apprehension felt about further dosage of the relaxant drug. The surgeon can begin and continue his examination under optimal conditions without the previous tiresome wait for the patient to begin breathing again after the injection of suxamethonium—meantime the peak of the relaxation period was passing him by. The equipment is simple, effective and inexpensive and is operated by a Boyle's apparatus which is universally available.

SUMMARY

A simple inflatable cuirass for use in maintaining ventilation during apnoea and relaxation under general anaesthesia for endoscopy has been described. A detailed account of its method of use is included.

ACKNOWLEDGMENTS

I wish to express my indebtedness to Dr. Gavin Young who encouraged me greatly by his pleasure in the results achieved with the cuirass. Equally I acknowledge with warm thanks the help given to me by Messrs. Medical & Industrial Equipment Ltd., who have arranged for the making of the cuirass and who have patiently accepted the various modifications.

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ON CHLOROFORM AND OTHER ANÆSTHETICS

THEIR ACTION AND ADMINISTRATION

BY

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(*Continued from page* 339)

In the first case, the pulse remained imperceptible for a period of four or five seconds, the countenance at the same time becoming deadly pale. As it returned it was at first very feeble, but in a few seconds, it regained its usual strength. In the second case, Dr. Simpson administered the chloroform, and after the operation remarked that the pulse had stopped suddenly just as the knife was piercing the thigh, and had recovered itself with a flutter almost immediately.

Mr. Bickersteth's reason for attributing the stoppage of the pulse to the effect of the knife, rather than the chloroform, was that he had arrived at the conclusion from some experiments which he performed on animals, that the action of the heart cannot be arrested by chloroform, until breathing has been first suspended. One of Mr. Bickersteth's experiments (No. 5, on a half-grown cat) exactly resembles the experiment (No. 28 in this work) on a rabbit, which I had published upwards of a year before Mr. Bickersteth's paper appeared, with the exception that in my experiment the artificial respiration was performed with air containing ten per cent. of vapour, and in Mr. Bickersteth's the vapour was an unknown quantity. In both experiments, the heart of the animal was exposed. In that which I performed, three or four inflations of the lungs almost paralysed the heart, and nine or ten inflations, which did not occupy half a minute, had the effect of paralysing that organ irrecoverably. In Mr. Bickersteth's experiment, the effect of the artificial respiration was as follows:—"After continuing it for seven minutes, the diaphragm, hitherto unaffected, began to move very irregularly and imperfectly; then its movements became slow and hardly perceptible; and, at the expiration of eleven minutes, they had ceased altogether. During all this time the heart's action remained strong and regular, but now it got weaker and more rapid, and, in four minutes from the time the diaphragm had ceased acting, had become so feeble (still quite regular) that I feared every moment it would stop." Mr. Bickersteth says he performed artificial respiration with air saturated with chloroform; but saturated or not, the vapour certainly did not exceed six per cent., and most likely was only between four and five, if the artificial resembled the natural respiration in quantity and frequency. The vapour which can be breathed for seven minutes without causing serious symptoms, and for eleven minutes without arresting the breathing, is of course incapable of stopping the action of the heart by its direct effect. It is scarcely so strong as that which one administers every day to patients with impunity. The vapour which is so diluted as to require to be added by

small increments during one hundred and fifty inspirations, before the brain is even narcotized, cannot act directly on the heart, an organ which can bear a much larger amount of chloroform. Mr. Bickersteth fell into the error into which the Committee of the Society of Emulation of Paris afterwards fell, and argued from the rule to the exception. What he witnessed was the mode of death which would occur, if vapour of chloroform of the strength which can be safely inhaled, were deliberately continued till the death of the patient. But an accident from chloroform is an exception, and the mode of dying is as much an exception as the death itself, if the inquiry is extended to what this agent is capable of doing, instead of confining it to what one endeavours to effect with it in the human subject alone.

So many of the deaths during the inhalation of chloroform have occurred before the operation had commenced, or after it had proceeded some way, that Mr. Bickersteth's explanation would not apply to a great number, even if it were correct; and when it is remembered that the operation is always commenced when the effect of the chloroform is expected to be at its height, the number of cases of cardiac syncope which have happened at the beginning of the operation is not greater than might be expected as the result of the effect of chloroform.

Sudden Death from other Causes. It has been more than once suggested that the deaths which have occurred, during the inhalation of chloroform, are of the same nature as the sudden deaths which have often occurred about the time of surgical operations, apparently without any adequate cause; and that in fact the accident and the chloroform may be a mere coincidence, and not connected as cause and effect. It has been already shown that the Commission of the Academy of Medicine of Paris made this suggestion in treating of the case Madlle. Stock, and Dr. Simpson has more than once made a similar remark. On one occasion,* he remarked, in speaking of chloroform: —" The first surgical cases in which it was used were operated upon in the Royal Infirmary here, on the 15th of November, 1847. Two days previously, an operation took place in the Infirmary, at which I could not be present, to test the power of chloroform; and so far fortunately so; for the man was operated upon for hernia, without any anæsthetic and suddenly died after the first incision was made through the skin, and with the operation uncompleted." I should say, so far unfortunately so, for whatever the cause of the man's death, that cause could hardly have been present if the patient had been made insensible by chloroform; and so his life would in all probability have been saved. If he died either from fear or from pain, the chloroform would have prevented his death, by removing and preventing these causes; and if his death arose from simple exhaustion, it must be remembered that chloroform is a stimulant, during the first part of its administration, and, as a general rule, so long as it is actually in the system. Even Mr. Bickersteth, who thinks that the knife of the surgeon may have a direct influence on the heart when the patient is quite insensible, expresses his conviction that such an occurrence is far less likely to happen

* Med. Times and Gaz., 1852, vol. i, p. 627.

under the influence of chloroform than in the waking state.

I have omitted from the list of deaths by chloroform two cases which are usually attributed to that agent, namely, the case of Mr. Robinson's patient, and the one at St. George's Hospital, and have attributed them to fear; and I also rejected the case of the infant on which Dr. Aschendorf operated, for the reasons I stated; and it is quite possible that amongst the fifty cases I have retained, there may be one or two in which the death was not caused by chloroform, especially as the details of some of the cases are very meagre; but when all the circumstances of the cases are examined, and especially when the mode of death is compared to that which chloroform can be made to produce in animals, it cannot be supposed that the fatal event was a mere coincidence in the whole fifty cases, or in any great number of them.

There are numerous instances recorded of sudden death during surgical operations, or just before intended ones, without any evident cause, except fear or pain, before the use of narcotic vapours was known; and some even since, in cases in which it was not thought worth while to use them. After the passage quoted above, Dr. Simpson continues:—"I know of another case in Edinburgh, where death instantaneously followed the use of an abscess-lancet without chloroform,—the practitioner, in fact, deeming the case too slight to require any anæsthetic." Such events have, no doubt, often happened without being recorded; and it is extremely likely that the deaths of this kind which chloroform has prevented are quite as numerous as those it has occasioned by its own effects, but the medical profession will very properly not be satisfied with a result of this kind, if more can be done; and the endeavour of the practitioner of course is, whilst saving life as well as preventing pain by the use of this agent, to avoid as far as possible having any accident from its use.

Falling back of the Tongue. It has been alleged that the falling back of the tongue into the throat, under the deep influence of chloroform, might be the cause of death by suffocation; but this appears to be an error; for the muscles of the larynx and neighbouring parts preserve their action as long as the diaphragm, and contract consentaneously with it. When the breathing has ceased, the tongue is indeed liable to fall backwards, if the person in a state of suspended animation is lying on the back, and this circumstance requires to be attended to in performing artificial respiration.

STATE OF THE CHIEF ORGANS AFTER DEATH FROM CHLOROFORM

A few years ago, I examined the viscera of the chest, and kept notes of the appearances, in thirty-seven animals killed by chloroform. They consisted of two dogs, twenty-two cats, one kitten, three rabbits, three guinea-pigs, two mice, two larks, and two chaffinches. Many of the animals were opened immedately after death, and the rest within a day or two. The lungs were not much congested in any instance. In seven of the animals, they were slightly congested; but in the remaining thirty, they were not congested. They were generally of a red colour, but in a few of the cats they were quite pale. I ascertained the specific gravity of the lungs of two of the cats, in which they presented the amount

of vascularity I have most usually met with. The specific gravity was 0.605 in one instance, and 0.798 in the other. As many of the animals died in a way resembling asphyxia, the respiration ceasing before the circulation, it might at first be supposed that we should meet with the same congestion of the lungs; but by the time that the respiration is altogether suspended by the action of chloroform, that agent has begun already to influence the heart, which does not inject the blood into the lungs with the same force as when the respiration is mechanically prevented, whilst it is in full vigour. Besides, in the gaspings which so often take place when the heart is ceasing to act, the animal inhaling chloroform draws air freely into the lungs, whilst the asphyxiated animal is prevented from doing so.

As regards the condition of the heart, it was found in the two chaffinches that the auricles were filled with blood whilst the ventricles were empty. The condition of the heart in the larks is not mentioned, but in all the thirty-three quadrupeds, the right auricle and ventricle were filled with blood. In ten of them, these cavities were much distended; and in some of these instances, the coronary vessels on the surface of the heart were distended also. The left cavities of the heart never contained more than a small quantity of blood, not exceeding a quarter of what they would hold.

The head was examined in only ten of the animals. The substance of the brain was found to be of the natural vascularity, and the sinuses were not very much distended, except in two instances.

With respect to the state of the blood, it may be mentioned, that in every instance in which the chest was opened within an hour after death, the blood which flowed from the cut vessels coagulater immediately and firmly. In eighteen of the animals in which the blood was examined in the heart or large vessels, a day or two after death, it was found to be well coagulated in ten, loosely coagulated in seven instances, and quite fluid in one instance. I have not met with air in the bloodvessels, either in the above thirty-seven examinations, or in any of the numerous other animals that I have opened, after they have been killed by chloroform. The appearances I have met with in animals killed by this agent have usually been such as I have described in the above thirty-seven instances; but I long since ceased, as a general rule, to make careful notes of the appearances, as I did not meet with anything new.

In the fatal cases of inhalation of chloroform previously quoted, the lungs are related to have been congested more frequently, and to a greater extent, than I have met with in animals. But there is no standard of what should be called congestion; and probably many of the medical men who made the examinations were speaking by comparison with cases where persons die after illness, in a state of inanition. In the human subject, the right cavities of the heart, although generally full of blood, were found empty in several cases; but as I previously stated, it is almost certain that they were emptied after death, either by the artificial respiration which was employed, or in some other way.

The blood remained fluid in eighteen out of twenty-five cases of fatal accident from chloroform in which an examination

of the body was made and the condition of the blood recorded; whereas it was only quite fluid in one instance out of eighteen of the animals which were killed by chloroform, and not opened till a day or two afterwards The fact of the blood coagulating more generally, in the animals on which I have experimented, than in the human subjects who died from chloroform, is probably due to their smaller size. I was formerly of opinion that the fact of the body of a small animal cooling more quickly than the human one was the probable explanation of this, but Dr. Richardson appears to have proved that the blood is kept in a liquid state by the presence of ammonia; and ammonia, we might expect, would escape more readily from the body of a small animal than from the human body. However this may be, it is pretty certain that the blood generally remains fluid in the human body after death from chloroform, only because it usually remains fluid in every kind of sudden death. When a patient dies slowly of illness, the body cools gradually before death takes place, and ammonia keeps exhaling in the breath, if Dr. Richardson is correct, whilst the formation of this alkali must be almost suspended. In many cases we know that coagulation of the blood commences before the respiration and circulation have ceased. The blood which flows during surgical operations coagulates as quickly and firmly when the patient is under the influence of chloroform as at other times; and, as was mentioned above, the blood which flows from animals, just after they are killed by this agent, coagulates as well as usual; it follows, therefore, that if the coagulation of the blood were prevented by the chloroform, and not by the mere fact of sudden death, it would be by the presence of this agent in the blood after death, and not by any action which it exerted during the life of the patient.

FURTHER REMARKS ON THE PREVENTION OF ACCIDENTS FROM CHLOROFORM

In consequence of the prevailing opinion that accidents from chloroform depend chiefly on the condition of the patient, the main endeavours to prevent a fatal result have taken the direction of a careful selection of the persons who were to inhale this agent. It may be doubted, however, whether this line of practice has had so much effect in limiting the number of accidents, as in curtailing the benefits to be derived from the discovery of preventing pain by inhalation. In nearly all the recorded cases of accident from chloroform, it is stated that the patients had been carefully examined, and such proofs of disease as were met with after death were chiefly those which had not been detected; and, as already has been stated, were probably not greater on an average than in the cases in which no accident happened.

I have not myself declined to give chloroform in any case in which a patient required to undergo a painful operation, whatever evidence of organic disease I have met with on careful examination; and although I have memoranda of upwards of 4,000 cases in which I have administered this agent, I have not, as I believe, lost a patient from its use; the only person who died whilst under its influence having, in my opinion, succumbed from other causes, as I have already explained.

Many writers have stated that accidents from chloroform might always be prevented by a close attention to the symptoms, or to some particular symptom, as the pulse or the breathing. Several authors have attached the utmost importance to feeling the pulse, and have considered this measure of itself sufficient to avert danger; whilst others have asserted that attention to the pulse is of no use at all. Mr. Bickersteth, for instance, writes as follows, in the article from which I previously quoted. "But the pulse should not be taken as any guide during the administration of chloroform. It should be wholly disregarded except under certain circumstances, when syncope is to be feared from loss of blood during the performance of a capital operation. The pulse is only affected secondarily in consequence of the failure of respiration."

If the person administering chloroform was always quite sure that the vapour did not constitute more than five per cent. of the inspired air, it is quite true that the pulse might be wholly disregarded. I can never produce more certain and uniform results with chloroform than when I am giving it to small animals enclosed in glass jars, where of course the pulse cannot be felt. In surgical practice, however, where the amount of vapour in the inspired air is often very uncertain, watching the pulse may be of great service, irrespective of loss of blood; and although it will not always prevent accident, I am persuaded that it has saved many lives. In some of the accidents that have happened, the pulse has ceased suddenly, whilst it was being very carefully watched; but more usually it would show some signs of failure before entirely ceasing.

In giving chloroform freely to animals from a napkin or sponge, whilst the ear or the hand was applied over the heart, I have usually found that its pulsations became embarrassed and enfeebled before they ceased; and by withdrawing the chloroform when the heart's action first became affected, the life of the animal could often be saved.

The importance of attending to the respiration of the patient has been previously noticed, and it is so obvious a symptom that it can hardly be disregarded, if anyone is watching the patient; it speaks, moreover, almost to one's instincts, as well as to one's medical knowledge. It is probable that no patient has been lost by disregard of the respiration, unless it be one or two whom no one was watching, or in which the head and shoulders were covered with a towel.

It has already been shown in this work, from experiments on animals, and from the physiological effects and physical properties of chloroform, that accidents from this agent would arise by its suddenly paralyzing the heart, if it were not sufficiently diluted with air; and a careful review of all the recorded cases of fatal accident shows that nearly every one of them has happened in this way, and not from any neglect in watching the symptoms induced, or mistaking their import.

The first rule, therefore, in giving chloroform is to take care that the vapour is so far diluted that it cannot cause sudden death, without timely warning of the approaching danger; and the next rule is to watch the symptoms as they arise. A

description of those symptoms, and what they indicate, has already been given.

I have previously stated that the most exact way of giving chloroform to a patient is to put so much of it into a bag or balloon as will make four per cent. of vapour when it is filled up with the bellows; but I have not often resorted to this plan, on account of its being somewhat troublesome. I have previously described* the inhaler which I employ. By arranging the bibulous paper suitably, and by ascertaining, with the inhaler in the scales, how much chloroform a given quantity of air carries off at different temperatures, I am able to produce very uniform results in the administration of chloroform. But, as I previously stated, those who do not wish to have the trouble of studying a suitable inhaler, may give chloroform on a handkerchief without danger, and with results sufficiently certain, by diluting this agent with an equal measure of spirits of wine. As the spirit (nearly all of it) remains behind, it is desirable, in a protracted operation, to change the handkerchief or sponge, now and then, for a dry one.

TREATMENT OF SUSPENDED ANIMATION FROM CHLOROFORM

It is probable that artificial respiration, very promptly applied, will restore all those patients who are capable of being restored from an overdose of chloroform. All the patients who are related to have been restored after this agent has occasioned a complete state of suspended animation, have been resuscitated by this means. It is only by artificial respiration that I have been able to recover animals from an overdose of chloroform, when I felt satisfied that they would not recover spontaneously. And under these circumstances I have not been able to restore them, even by this means, except when a tube had been introduced into the trachea, by an incision in the neck, before giving them what would have been a fatal dose.

M. Ricord succeeded in restoring two patients who were in a state of suspended animation by mouth to mouth inflation of the lungs. The first was a woman, aged twenty-six, who had been made rapidly insensible by a few inspirations of chloroform from a sponge. He had scarcely commenced the operation of removing some vegetations, when his assistant informed him that the pulse had ceased. The breathing also ceased about the same time.

In the second case, he completed the operation of circumcision, and the patient, a young man, not coming to himself, M. Ricord found that the breathing had ceased, and the pulse was becoming more and more extinct, and very soon ceased entirely, till restored by the artificial respiration.

After these cases, hopes were expressed that M. Ricord had discovered the means by which all patients might be restored from the overaction of chloroform; but these hopes have not been verified by events. In the first of the cases, the heart had probably not been so entirely paralyzed by the action of the vapour as sometimes happens, and in the second case, that organ was apparently not paralyzed by the chloroform at all. It was only after the breathing had ceased, that M. Ricord found the pulse was failing. This was a case, therefore, in which artificial respira-

* *Brit. J. Anaesth.* (1955), **27**, 192.

tion might reasonably be expected to restore the patient.

The following cases of resuscitation, from the over effects of chloroform, are related by Mr. Bickersteth in the paper previously quoted. They occurred in Edinburgh:

"*Case* 1. A boy was cut for stone by my friend Mr. Hakes, on the 29th of March, 1849. Chloroform was administered on a piece of sponge, and the full anæsthetic effect produced, before proceeding to tie him up in the ordinary position: the inhalation was continued, without any regard to his condition, until the operation had been completed—altogether about five minutes from the time he first became insensible. It was noticed that during the operation scarce a drop of blood escaped. When it was over, the child was found, to all appearance, dead; the muscles were flaccid; the surface of the body pale; the respiration had ceased; the pulse could not be felt; the heart sounds were not audible (but the room was by no means quiet); the eyes were half open; the jaw dropped; the pupils dilated; and the corneæ without their natural brilliancy. Several means were tried to resuscitate him, but without effect. At length artificial respiration was commenced; the air escaped with a cooing sound, as if from a dead body. After continuing it for a while, the breathing commenced, at first very slowly and feebly. Soon it improved. In two hours the child had quite recovered."

"*Case* 2. In December 1851, a child, a few months old, was put under the influence of chloroform for the purpose of having a nævus removed from the right cheek. As soon as insensibility was produced, the operation was commenced—the handkerchief containing the chloroform remaining over the face, as some difficulty had been experienced in keeping up the anæsthetic effect. Suddenly the breathing ceased; the muscles became flaccid the countenance pale and collapsed, and the lips of a purple colour. Artificial respiration was employed, and in less than a minute the breathing returned, and the child was restored."

(*To be continued*)

DOSES OF CURARE

Sir,—The case so amply criticized by Dr. Wislicki (*Brit. J. Anaesth.* (1957), **29**, 228) was one of a series presented to illustrate a hypothesis (Foster, 1956) and not to advocate a technique. Accordingly, no comment was then offered on the methods used unless related to the subject. Some of what Dr. Wislicki has written may be justified, although not always relevant to a plea for reduction of the doses of curare. One feels that mention could have been made with advantage and appositeness, to the role of excessive premedication in inducing apnoea in frail people (cf. Dekornfeld, 1957) or to the part played by large doses of neostigmine in producing circulatory collapse and persistent curarization.

On one point I wish to challenge Dr. Wislicki's attempt at long range telepathic diagnosis. Even by quoting this case report out of the context of its article, it is still not reasonable to assert that the patient was awake (presumably meaning fully conscious) for a long period of the anaesthetic.

One adduced from the reports of the other cases recovering after this type of reaction, together with familiarity with the technique used (the context) that this patient was unconscious, but with a peculiar pattern of motor activity, the possible nature of which was discussed. The point was made, and perhaps it was not unimportant, that such patients are not conscious, do not require immediate further doses of relaxants, and because this motor reaction is transient, do not need heavy doses of supplementary drugs. Subsequent experience has confirmed this view: a grasp reflex need not indicate the anguished grip of a conscious patient, nor a present lid reflex a state of wakefulness, and the only patient seen who was dimly conscious of pain under nitrous oxide and relaxant anaesthesia (due to faulty apparatus) made none of these indications. In any case, these reflexes can be controlled by slightly deepening the gas narcosis or by the use of small doses of thiopentone (50 mg) or pethidine (20 mg). Large doses of drugs as suggested by Dr. Wislicki are usually unnecessary and potentially dangerous.

Nevertheless, it might be profitable to follow the implication of this (Dr. Wislicki's) assumption. An old, frail, and heavily premedicated man is given a constant concentration of nitrous oxide (75 per cent) in oxygen to breathe after lung denitrogenation. He loses consciousness on this mixture. But after receiving a normally fully paralysing dose of dtc, he stays awake for the next twenty minutes despite the constancy of the gas mixture and the fact that controlled ventilation ensures that his gas uptake is probably more effective after induction than before. Does this indicate a specific central antagonism between nitrous oxide and dtc, or grounds for believing that nitrous oxide resistance existed in a type of patient usually found to be most susceptible to anaesthetics? Or may one compare at least this slowly developing depression in a man with recent work in dogs indicating that dtc has a depressant central effect whose slow onset is delayed up to twenty minutes after intravenous injection (Lape, Fort and Hoppe, 1957).

In case other readers of this journal are also unfamiliar with this nitrous oxide technique, one should mention that it may be used satisfactorily in unpremedicated outpatients for minor operations, or for Caesarean section with only atropine premedication. Again, it appears as a method of choice for major intrathoracic surgery (Gray and Riding, 1957) whose paper includes a detailed account of the technique. Since unconsciousness is not initially produced by hypoxia, as in older hypoxic gas techniques, there is little chance of partial reawakening as seen when oxygen is readmitted in increasing percentage.

There must be an increasing number of anaesthetists who show great caution in the use of relaxants in the metabolically deranged patient (Editorial, 1956; Burchell, 1957) especially after the recent paper by Hunter (1956) and the subsequent correspondence evoked. But if this caution entails (as featured in Dr. Wislicki's case 1) the use of 850 mg thiopentone, 100 mg pethidine, ether, 12 mg dtc, and 80 mg gallamine in a very ill, elderly patient during 110 minutes, then caution must have been thrown to the winds.

The problem of relaxant dosage to such critically ill people is not entirely related to the use of these drugs in routine anaesthesia, and Dr. Wislicki's discussion does not always make this distinction. When dealing with patients in reasonably good physical status, it should clearly be emphasized that reduction of the dose of relaxant is achieved only at the expense of increasing doses of other drugs with more diverse effects. This is clear when referring to the authors quoted by Dr. Wislicki.

Patterson (1952) is mentioned as advocating doses of 3–9 mg dtc, but it should also have been mentioned that this author seemed to rely, in his technique, upon unlimited quantities of thiopentone. Sadove et al. (1955), quoted incorrectly as using from 6 to 8 mg dtc (this drug was not mentioned in the article), in addition relied upon 500 mg thiopentone, ether, and relatively large doses of intravenous procaine (1.5 g) with nitrous oxide. These authors note that " procaine seemed to potentiate markedly the action of the muscle relaxant used during induction," and indeed it is an observation of some anaesthetic antiquity that procaine is an antidepolarizing agent in mammalian muscle with curare potentiating properties (Harvey, 1939; de Elio, 1948; Burn, 1952). Such use of drugs, especially when involving powerful and not always predictable curare potentiating agents, seems to offer little advantage in safety or facility of technique over the isolated case report of Grigor (1954). Here 400 mg thiopentone, 35 mg dtc, 50 mg pethidine with nitrous oxide narcosis and 250 mg intravenous procaine were used. Is it better to use procaine and ether to potentiate a dose of relaxant inadequate for one's purpose?

On considering the undesirable side effects of large doses of thiopentone, pethidine, intravenous local analgesics, and of ether mixed with relaxants, Dr. Wislicki's plea is perhaps not so convincing, especially so since it was to avoid such side effects that large doses of relaxants with nitrous oxide were originally given. Whether the alternative technique she offers for the seriously ill patient will prove acceptable, is also doubtful for the same reasons. Perhaps the answer will lie in the use of cyclopropane potentiated nitrous oxide anaesthesia with Mylaxen (hexafluorenium), or some similar agent whose relaxant effect can be reversed by lightening anaesthesia (Cavallito, Arrowood, and O'Dell, 1956).

P. A. FOSTER.

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Gas and Air; Trilene for the Relief of Pain in Labour; Lower Segment Caesarean Section; and *Pre-operative and Postoperative Care.* Film strips supplied by Camera Talks, 23 Denmark Place, London, W.C.2.

In preparing any publication (including films) it is essential first to decide for whom it is intended and to proceed accordingly. The major failing in these film strips is that they do not seem to be planned for any specific audience. Parts of some of them may be excellent for postgraduates, while the same strip may contain pictures which would be more suitable for a lay audience.

Gas and Air (58 frames, black and white).

This film was produced under supervision of Dr. R. J. Minnitt at Liverpool Maternity Hospital. It opens with various analgesic apparatus, all modifications of the original Minnitt machine, and roughly outlines their mechanisms. The visit of the midwife to the patient's home is next shown, demonstrating antenatal tuition in the handling of the apparatus. Pictures of the three stages of labour follow, including the birth of the baby and delivery of the placenta, with the appropriate use of gas and air analgesia in each stage. The strip ends with four shots to illustrate cleansing of the face mask.

This can hardly be considered technical enough for midwives or medical students, except as an introduction to the subject at the beginning of their training. It would probably be too gruesome for a lay audience, but excellent for an antenatal audience. The photography is extremely good, but an appropriate number of frames could be omitted without losing continuity.

Trilene for the Relief of Pain in Labour (25 frames, colour).

This film was prepared at the Hammersmith Hospital and the first fourteen shots are devoted to the Freedman, Emotril, Cyprane and Tecota vaporizers. These may be useful for medical students, midwives or postgraduate obstetrical or anaesthetic students. The remaining eleven frames show long range shots of a delivery under trichloroethylene analgesia and are not sufficiently detailed to be of value to any of the above audiences.

While the photography of the labour is good, some of the earlier shots of the apparatus are over exposed and it is regrettable to find that the order does not always agree with the manual which accompanies the film strip.

Lower Segment Caesarean Section (24 frames, colour).

The film shows a lower segment caesarean section under local analgesia for benign hypertension carried out by Mr. Robert Percival. The accompanying manual gives a detailed case history including the pre-operative medication with pethidine and nalorphine, although the dosage is not stated. Apart from showing the position of of the skin weals, there are no details of the technique of local anaesthesia and the majority of the shots are concerned with the operation. It is doubtful whether enough operative details are shown for this to be of value in teaching the details of the operation, and it is quite useless for demonstrating the technique of local anaesthesia.

With a suitable commentary, discussing the indications for local anaesthesia and for Caesarean section this should be useful for medical students or pupil midwives. It might be of value for antenatal instruction, in order to explain precisely what caesarean section means, but the one view which is given of the mother is highly suggestive of the presence of cyanosis. The photography is excellent throughout, but once again the sequence of slides is not quite similar to that in the manual.

Pre-operative Care (43 frames, black and white) and *Postoperative Care* (38 frames, black and white).

Both these films were prepared at Mile End Hospital. The accompanying manual suggests that both of these are prepared for nurses and this is emphasized by the details shown of such pro-

cedures as preparing the bed, preparing the skin and caring for the unconscious patient. One could criticize a few points, such as the nurse and porter carrying the unconscious patient unaided, or the administration of glucose in the morning without reference to the proposed time of the operation; but apart from these details the films are excellent. They would also be good for medical students and even the most apprehensive patient would benefit from seeing the excellent care which he can expect before and after his operation.

John W. Dundee

BOOK REVIEW

Fluid Balance in Surgical Practice (2nd edition). By L. P. LeQuesne, D.M.(Oxon), F.R.C.S. (Eng.). Published by Lloyd Luke. Price 20*s*.

The second edition of this excellent book is only slightly larger than the first; the table of contents is exactly the same but for the chapter on the fluid balance in children which is now written by Dr. B. W. Webb. There are some other changes. Aldosterone appears for the first time as the hormone of the adrenocortical extract having the greatest influence on the renal excretion of electrolytes; the second chapter on the effects of operation on water and electrolyte balance has been rearranged and small additions and subtractions made in the text; a couple of pages have been added to chapter three and the one on nitrogen and calorie problems considerably expanded. A much more detailed explanation of how the balance tables are made up would be helpful; for example a specimen balance sheet should have the figures of the amount of salt given and the amount of salt excreted in addition to the cross hatching already pictured. Again, on page 77 it is stated that the total amount of potassium in a 70 kg man is 3,400 m.equiv. at a concentration of 150 m.equiv. per litre, almost all of it in the intracellular fluid. We are also told that there are 35 litres of intracellular fluid. The discrepancy is considerable.

E. Falkner Hill

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